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PHOSPHORUS REMOVAL EFFICIENCY UPGRADING AT MUNICIPAL WASTEWATER TREATMENT PLANTS IN THE GREAT LAKES BASIN

SUMMARY REPORT

Technical Report

FEBRUARY 1988

Canada Ontario

Canada-Ontario Agreement Respecting Great Lakes Water Quality
L'Accord Canada-Ontario relatif à la qualité de l'eau dans les Grand Lacs

PHOSPHORUS REMOVAL EFFICIENCY UPGRADING AT MUNICIPAL WASTEWATER TREATMENT PLANTS IN THE GREAT LAKES BASIN

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EXECUTIVE SUMMARY

1.0 BACKGROUND AND OBJECTIVES

The overall goal of the investigation, as part of the Canada-Ontario Phosphorus Load Reduction Plan for the Great Lakes Basin, was to establish the most cost-effective strategy of phosphorus management for municipal wastewater treatment facilities in Ontario. The study was based on a historical data review, field surveys and actual full-scale demonstrations of optimized phosphorus control techniques.

The investigation was undertaken in three phases. Phase 1 of the study program involved an in-depth review of historical plant performance data for municipal water pollution control plants (WPCPs) in the Great Lakes drainage basin with design flows greater than 4546 m^3/day. Phase 2 of the study program involved field evaluations at selected WPCPs to establish the critical factors affecting phosphorus removal performance. Twelve facilities were selected based on the historical data review undertaken in Phase 1. Phase 3 of the study program was intended to demonstrate that phosphorus removal performance improvements could be cost-effectively achieved in most cases by low capital cost measures. Four plants which had been evaluated in Phase 2 were selected for more detailed investigation during Phase 3.

This final project report summarizes the findings of each phase of the investigation. Based on these findings, a phosphorus management strategy for municipal wastewater treatment facilities in Ontario was developed and approaches to cost-effectively upgrade phosphorus removal efficiency at existing facilities were suggested.

2.0 HISTORICAL PLANT PERFORMANCE EVALUATIONS

Ninety-six municipal treatment facilities with design capacity greater than 4546 m^3/day (1 MGD) discharging to the International section of the Great Lakes drainage basin were included in the performance evaluation. The assessment focussed on years 1981 to 1985.

The historical data review showed that there was a general improvement in plant performance over the assessment period, based on the number of plants complying with effluent guidelines for BOD_5, TSS and total phosphorus (TP). There were significantly more plants that did not comply with effluent total phosphorus guidelines than did not comply with effluent BOD_5 and TSS guidelines in all years evaluated. The data review also showed that a compliance assessment based on monthly averages instead of annual averages would increase the number of plants not complying, particularly in the case of TP requirements.

3.0 BASIN PHOSPHORUS LOADINGS

Total phosphorus loadings to the Lake Erie Basin from municipal WPCPs were relatively unchanged over the period from 1981 to 1985. Further loading reductions from these sources will be difficult to achieve by low capital costs measures because of the superior performance of these facilities.

Total phosphorus loadings to the Lake Ontario/St. Lawrence River Basin from municipal WPCPs have declined over the time period studied. In this basin, where several large facilities did not comply with the annual average effluent requirement of 1 mg/L in 1983, the basin loading could be substantially reduced by bringing all facilities into compliance with the existing guidelines.

Total phosphorus loadings to the Lake Huron Basin have increased since 1982 where four facilities (Port Elgin, Sault Ste. Marie, Sudbury and Mikkola) had not implemented phosphorus removal by 1985. Loadings to the Lake Superior Basin have declined over the same period.

4.0 FIELD INVESTIGATIONS

The field investigations indicated that the three most common causes of inadequate phosphorus removal performance at municipal facilities were inadequate chemical dosage, excessive hydraulic loading on secondary clarifiers and inadequate sludge management practices. Higher chemical

dosages can often compensate for short-term TP excursions due to hydraulic overloading. However, consistent compliance with a monthly effluent TP requirement of 1 mg/L will be difficult in WPCPs which experience extended periods of high hydraulic loading or which have design or operational problems which limit sludge processing capacity.

Upgrading the performance of existing facilities will necessitate better monitoring of process operation and better control of chemical dosage. Best Management Practice (BMP) should include weekly composite sampling of effluent quality, analyses by the operating authority for total and soluble phosphorus fractions in effluent samples using appropriate analytical methods, improved laboratory QA/QC programs and routine adjustment of chemical dosage rates in response to the results of the process monitoring.

5.0 PHOSPHORUS MANAGEMENT STRATEGIES

Four phosphorus management strategies were evaluated in terms of the impact on phosphorus loadings to the Lake Erie Basin and the Lake Ontario/St. Lawrence River Basin. These strategies are summarized below:

SCENARIO	STRATEGY
0	Basin loadings as actually experienced in 1984 and 1985.
1	All plants comply with effluent TP $\leq$ 1 mg/L on an annual average basis, or their site-specific requirements.
2	All plants comply with effluent TP $\leq$ 1 mg/L on a monthly average basis, or their site-specific requirements.
3	All plants with design capacity >100,000 m^3/d in the Lake Erie drainage basin and >200,000 m^3/d in the Lake Ontario drainage basin comply with effluent TP $\leq$ 0.9 mg/L on a monthly average basis. All other plants comply on a monthly basis with TP $\leq$ 1 mg/L, or their site-specific requirements.
4	All plants comply with effluent TP $\leq$ 0.9 mg/L on a monthly average basis, or their site-specific requirements.

Each strategy was evaluated in terms of its ability to maintain the basin loading at its 1983 level. In all cases, plants which were presently meeting the effluent requirement were assumed to maintain that performance level.

This analysis showed that, for the Lake Erie Basin, none of the management strategies would be able to maintain the 1983 phosphorus loading level to beyond approximately 1989 or to a total basin flow of approximately 950,000 m^3/d. Because the large WPCPs in this basin achieved an aggregate average total phosphorus concentration of 0.89 mg/L in 1983, maintaining this loading level with projected future flow increases may require longer term capital-intensive plant upgrading.

In the Lake Ontario/St. Lawrence River Basin, all of the phosphorus management strategies assessed would result in the 1983 basin loading level being maintained to beyond 1990 or until the flow reaches approximately 3,000,000 m^3/d. Imposition of a monthly-based compliance requirement of 1 mg/L would maintain the 1983 loading level until about 1995 (equivalent to a basin flow of 3,200,000 m^3/d), five years longer than would be achieved with the present annual compliance requirement. The more stringent control strategies maintain the 1983 loading level for only about 2 years longer than would be achieved by the monthly-based compliance requirement of 1 mg/L.

Imposition of a monthly-based compliance requirement of 1 mg/L TP is the most cost-effective management strategy for the Lake Ontario/St. Lawrence River Basin. To provide a consistent policy on phosphorus removal, this requirement should also be imposed on WPCPs discharging to the Lake Erie Basin; however, it should be recognized that in this case, this strategy will only maintain the target loading until 1988. The phosphorus loading allocations and loading limits for the Lake Erie Basin should be reassessed in light of the potential costs of further municipal loading reductions.

ACKNOWLEDGEMENT

We would like to acknowledge the cooperation of WPCP management and operational staff who provided information on phosphorus removal approaches during Phase 1 of the project and who provided assistance during the field work in Phase 2 and 3.

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1.0 INTRODUCTION

1.1 Background to the Study

After completion in 1969 of a six year study of pollution in the Lower Great Lakes Drainage Basin, the International Joint Commission (IJC) recommended that all phosphorus discharges be reduced to their "lowest practical level". Subsequently, a number of organizations responded to this recommendation. The Canada Water Act (1970), of the Government of Canada, called for a staged reduction in phosphorus levels in detergents to a final limit of 5 percent (by weight as P_2O_5) by 31 December 1972. The Canada-Ontario Agreement on Great Lakes Water Quality, signed in August 1971, stipulated that phosphorus removal be implemented at selected municipal wastewater treatment facilities in the Lake Erie watershed by 31 December 1973 and in the Lake Ontario watershed by 31 December 1975. The Province of Ontario stated their intention to install phosphorus removal facilities at municipal and institutional wastewater treatment plants in the Lower Great Lakes basin, as well as the Ottawa River basin, parts of the Upper Great Lakes basin and throughout the inland recreational areas.

As an initial policy, the Province of Ontario required a minimum of 80 percent phosphorus removal from wastewater treatment plant influents, subject to further study. In April 1972, a Great Lakes Water Quality Agreement between Canada and United States superseded the Ontario policy and limited effluent phosphorus concentrations to a daily average of 1 mg/L, assessed on an annual average basis, for wastewater treatment plants discharging in excess of one million gallons per day (4546 m^3/d) to Lake Erie, Lake Ontario and the International section of the St. Lawrence River.

In 1978, the Canada-United States Great Lakes Water Quality Agreement set Target Phosphorus Loads for all of the Great Lakes basins. These total loads, from point and non-point sources, were 11,000 tonnes/year to Lake Erie, 7,000 tonnes per year to Lake Ontario, and a total of 8650 tonnes per year to the Upper Great Lakes. In October 1983, amendments to the Canada-United States Agreement on Great Lakes Water Quality (Phosphorus Load Reduction Supplement to Annex 3) stated that further reductions to the total phosphorus loadings being discharged by Canada and United States to the Great Lakes would have to be achieved. Specifically, reductions of 2000 tonnes/ year to the Lake Erie drainage basin and 430 tonnes/year (revised from 1210

specified in the Agreement) to the Lake Ontario drainage basin were required. Canada's allocation of the loading reduction to the Lake Erie basin was set at 300 tonnes/year. The Canadian component of the reduction to the Lake Ontario basin was not specified in the Agreement.

The requirements of the "Phosphorus Load Reduction Supplement" are being implemented in Canada under the Canada-Ontario Agreement (COA). To this end a Federal/Provincial Task Force was established to develop a phosphorus reduction plan*. Under the plan, municipal, industrial and agricultural cropland phosphorus loadings would be reduced to achieve the reductions specified in the Canada/United States Agreement. The 1986 COA provides for federal/provincial funding of specific components of this plan.

The phosphorus reduction plan requires all municipal wastewater treatment plants 1 MGD or larger to meet an effluent requirement of 1.0 mg/L total phosphorus. In addition, phosphorus loadings from municipal wastewater treatment facilities are to be reduced by 30 tonnes per year in the Lake Erie Basin and 50 tonnes per year in the Lake Ontario Basin. These would be achieved by voluntarily reducing the aggregate average effluent concentration to 0.9 mg/L in Lake Erie and 0.95 in Lake Ontario. Using the 1983 flows and the reduced aggregate effluent concentration for all plants 1 MGD or larger in the Lake Erie and Ontario basins, loading reduction of 30 and 50 tonnes respectively would result.

It was realized at that time that flows to wastewater treatment plants would increase each year and a more comprehensive phosphorus management strategy would have to be developed. This three-phase study program was undertaken by CANVIRO Consultants on behalf of the Ontario Ministry of the Environment (MOE) to identify the most cost-effective phosphorus management strategy to achieve the phosphorus loading reduction goals.

1.2 Objectives of the Study

The overall goal of the investigation was to establish the most cost-effective strategy of phosphorus management for municipal wastewater treatment facilities in Ontario, based on historical data review, field surveys and actual full-scale demonstrations of optimized phosphorus control techniques.

*Canadian Federal/Provincial Phosphorus Load Reduction Plan for the Great Lakes Basin - April 1985.

The principal objectives proposed for this study were:

(i) Identify major facilities in the four Great Lakes Basins (Superior, Huron, Erie and Ontario) consistently not meeting the 1.0 mg/L annual requirement, as well as facilities consistently producing effluents of less than 1.0 mg/L total phosphorus.

(ii) Determine the most cost-effective operations and/or simple process modifications that would significantly improve phosphorus removal in selected facilities (in the two lower Great Lakes Basins only).

(iii) Recommend the best abatement strategies for basin-wide phosphorus removal management and project annual operating cost requirements.

(iv) Demonstrate and confirm the practicality and effectiveness of the recommended changes in selected facilities in the Lower Great Lakes Basins.

(v) Identify the number of facilities which may fail to comply with the 1.0 mg/L effluent phosphorus concentration should the assessment method change from annual average basis to monthly average basis, and compare non-compliance numbers for both methods of assessment.

(vi) Recommend changes required to reduce the number of facilities failing to comply with the phosphorus requirements, under the new assessment method, to the same level or better than in the past, and project the increase in operating costs required by the recommended changes.

1.3 Study Scope

The investigation was undertaken in three phases. The initial phase (Phase 1) of the program involved an in-depth review of historical plant performance data for municipal water pollution control plants (WPCPs) in the Great Lakes drainage basin with design flows greater than 4546 m^3/day. A preliminary assessment of the alternative management strategies available was also undertaken. The results of this component of the investigation were presented to MOE in a Phase 1 report in November 1986[1].

Phase 2 of the study program involved field evaluations at selected WPCPs to establish the critical factors affecting phosphorus removal performance. Twelve facilities were selected based on the historical data review

undertaken in Phase 1. Five plants were included which had demonstrated superior phosphorus removal performance - Port Dalhousie WPCP, Fergus WPCP, Midland WPCP, Port Hope WPCP and Trenton WPCP. Seven plants were included which had consistently had difficulty complying with the 1 mg/L total phosphorus requirement - Collingwood WPCP, Moore Township (Corunna) WPCP, St. Thomas WPCP, Toronto Humber WPCP, Toronto Main WPCP, Duffin Creek WPCP and Esten Lake WPCP. The results of these field evaluations were presented to MOE in a Phase 2 report in February 1987[2].

Phase 3 of the study program was intended to demonstrate that phosphorus removal performance improvements could be cost-effectively achieved in most cases by low capital cost measures. Four plants which had been evaluated in Phase 2 were selected for more detailed investigation during the Phase 3 portion of the study, namely the Collingwood WPCP, Duffin Creek WPCP, Toronto Humber WPCP and Toronto Main WPCP. The results of these investigations were presented to MOE in a Phase 3 report in June 1987[3].

1.4 Report Format

This final project report summarizes the findings of each phase of the investigation. Based on these findings, a phosphorus management strategy for municipal wastewater treatment facilities in Ontario is developed and approaches to cost-effectively upgrade phosphorus removal efficiency at existing facilities are suggested. Detailed discussions of the project methodology have been presented in the reports on the individual project phases [1,2,3].

The results of the historical data review are summarized in Section 2.0 of the report. The findings of the field investigations are presented in Section 3.0. Alternate phosphorus loading management strategies are discussed in Section 4.0, along with a review of cost and implementation implications. The conclusions and recommendations resulting from the study are presented in Section 5.0.

2.0 HISTORICAL PLANT PERFORMANCE EVALUATIONS

2.1 Objectives and Approach

Historical performance data for 98 WPCPs with design flows greater than 4546 m^3/d (1 MGD) in the Upper and Lower Great Lakes Basins which were required to achieve an effluent phosphorus limit of 1 mg/L were analyzed to determine the compliance status of these facilities relative to their effluent guidelines for the period 1981 to 1985. Phosphorus removal procedures at each plant were reviewed with the objective of identifying critical factors influencing the efficiency of phosphorus removal at each facility.

The facilities included in the review are identified in Table 1. A detailed discussion of the data collection and analysis procedures was presented in the Phase 1 report (1).

2.2 Performance Review

In 1985, there were 96 municipal treatment plants with design capacity greater than 4546 m^3/day (1 MGD) discharging to the International section of the Great Lakes drainage basin. These included 44 plants in the Lake Ontario/St. Lawrence drainage basin (Newmarket WPCP was not operational in 1985), 31 in the Lake Erie drainage basin, 20 in the Lake Huron drainage basin (Elliot Lake Plant 2 was not operational in 1985) and 1 in the Lake Superior drainage basin. Of these, 83 plants provided secondary treatment, while 13 provided primary treatment. None of the 4 sewage lagoons in the Great Lakes Basin with capacities greater than 4546 m^3/day (1 MGD) (Strathroy lagoon, Listowel lagoon, Kincardine lagoon and Lindsay lagoon) were included in this review because of the paucity of operational data for these facilities. All of the plants, their design capacity and type, and the chemicals used for phosphorus removal at each plant are listed in Tables 2 to 4. Figure 1 indicates the location of each plant.

Average daily flow and average effluent quality characteristics for 1981 to 1985, obtained from the annual performance data review prepared for each plant, are summarized in Tables 5 to 7. Also included in these summary tables is the 5 year long-term average daily flow and effluent quality for each facility.

TABLE 1. WPCPs INCLUDED IN PERFORMANCE ANALYSIS

LAKE ERIE BASIN	LAKE HURON BASIN	LAKE ONTARIO/ST. LAWRENCE BASIN	LAKE SUPERIOR BASIN
Amherstburg WPCP	Barrie WPCP	Belleville WPCP	Thunder Bay WPCP
Brantford WPCP	Bradford WPCP	Brockville WPCP	
Galt WPCP (Cambridge)	Collingwood WPCP	Burlington WPCP	
Hespeler WPCP (Cambridge)	Esten Lake WPCP (Elliot Lake)	Caledon WPCP (Bolton)	
Preston WPCP (Cambridge)	Plant Two (Elliot Lake)	Campbellford WPCP	
Chatham WPCP	Goderich WPCP	Cobourg WPCP No.1	
Dresden WPCP	Hanover WPCP	Cornwall WPCP	
Dunnville WPCP	Huntsville WPCP	Dundas WPCP	
Fergus WPCP	Midland WPCP	Anger Ave. WPCP (Fort Erie)	
Guelph WPCP	North Bay WPCP	Baker Rd. WPCP (Grimsby)	
Ingersoll New WPCP	Orillia WPCP	Acton WPCP & Lagoon (Halton Hills)	
Kitchener WPCP	Owen Sound WPCP	Georgetown WPCP (Halton Hills)	
Leamington WPCP	Parry Sound WPCP	Woodward Ave. WPCP (Hamilton)	
Adelaide WPCP (London)	Port Elgin WPCP	Iroquois WPCP	
Greenway WPCP (London)	Sault Ste. Marie WPCP	Kingston WPCP	
Oxford WPCP (London)	Sturgeon Falls WPCP	Kingston TWP WPCP	
Pottersburg WPCP (London)	Sudbury WPCP	Highland Creek WPCP (Metro Toronto)	
Vauxhall WPCP (London)	Hamner, Val-Caron, Val-Therese WPCP (Valley East)	Humber WPCP (Metro Toronto)	
Belle River-Maidstone WPCP	Mikkola WPCP (Walden)	Main WPCP (Metro Toronto)	
Corunna P.V. WPCP (Moore)	Walkerton WPCP	North Toronto WPCP (Metro Toronto)	
Paris WPCP	Wasaga Beach WPCP	Milton WPCP	
Sarnia WPCP		Clarkson WPCP (Mississauga)	
Simcoe WPCP		Lakeview WPCP (Mississauga)	
St. Thomas WPCP		Napanee WPCP	
Stratford WPCP		Port Darlington WPCP (Newcastle)	
Tillsonburg WPCP		Newmarket WPCP	
Wallaceburg WPCP		Stamford WPCP (Niagara Falls)	
Waterloo WPCP		South East WPCP (Oakville)	
Little River WPCP (Windsor)		South West WPCP (Oakville)	
Westerly WPCP (Windsor)		Orangeville WPCP	
Woodstock WPCP		Harmony Cr. WPCP No.1 (Oshawa)	
		Harmony Cr. WPCP No.2 (Oshawa)	
		Peterborough WPCP	
		York-Durham WPCP (Pickering)	
		Picton WPCP	
		Seaway WPCP (Port Colborne)	
		Port Hope WPCP	
		Prescott-Edwardsburgh WPCP	
		Port Dalhousie WPCP (St. Catharines)	
		Port Weller WPCP (St. Catharines)	
		Trenton WPCP	
		Welland WPCP	
		Corbett Cr. WPCP (Whitby)	
		Pringle Cr. WPCP No.1 (Whitby)	
		Pringle Cr. WPCP No.? (Whitby)	

TABLE 2. WPCPs IN THE LAKE ERIE DRAINAGE BASIN - DESIGN FLOW, PLANT TYPE AND CHEMICALS USED FOR PHOSPHORUS REMOVAL

PLANT	DESIGN FLOW (10^3 m^3/d)	PLANT TYPE	CHEMICAL PRESENTLY USED FOR PHOSPHORUS REMOVAL
Amherstburg WPCP	4.546	Primary, phosphorus removal - continuous	Ferric Chloride
Brantford WPCP	81.828	Conventional activated sludge, phosphorus removal - continuous	Ferrous Chloride
Galt WPCP (Cambridge)	36.641	Conventional activated sludge, phosphorus removal - continuous	Ferric Chloride
Hespeler WPCP (Cambridge)	9.319	High rate activated sludge, phosphorus removal - continuous	Ferric/Ferrous Chloride
Preston WPCP (Cambridge)	16.866	Conventional activated sludge, phosphorus removal - continuous	Ferric Chloride
Chatham WPCP	35.913	Conventional activated sludge, phosphorus removal - continuous, effluent polishing	Ferrous Chloride
Dresden WPCP	4.546	Extended aeration, phosphorus removal - continuous	Aluminum Chloride
Dunnville WPCP	7.728	Conventional activated sludge, phosphorus removal - continuous	Ferrous Chloride
Fergus WPCP	5.001	Conventional activated sludge, phosphorus removal - continuous	Ferrous Chloride
Guelph WPCP	54.552	Conventional activated sludge, phosphorus removal - continuous, effluent polishing	Alum
Ingersoll New WPCP	6.819	Conventional activated sludge, phosphorus removal - continuous	Ferrous Chloride
Kitchener WPCP	122.742	Conventional activated sludge, phosphorus removal - continuous	Ferrous Sulphate
Leamington WPCP	19.093	Conventional activated sludge, phosphorus removal - continuous	Ferric Chloride
Adelaide WPCP (London)	18.184	Conventional activated sludge, phosphorus removal - continuous	Ferrous Chloride
Greenway WPCP (London)	123.333	Conventional activated sludge, phosphorus removal - continuous	Ferrous Chloride
Oxford WPCP (London)	5.455	Conventional activated sludge, phosphorus removal - continuous	Ferrous Chloride
Pottersburg WPCP (London)	22.048	Conventional activated sludge, phosphorus removal - continuous	Ferrous Chloride
Vauxhall WPCP (London)	20.912	Conventional activated sludge, phosphorus removal - continuous	Lime
Belle River-Maidstone WPCP	6.819	Extended aeration, phosphorus removal - continuous	Alum
Corunna P.V. Plant (Moore)	4.546	Extended aeration, phosphorus removal - continuous	Alum
Paris WPCP	7.046	Extended aeration, phosphorus removal - continuous	Ferric Chloride
Sarnia WPCP	65.917	Primary, phosphorus removal - continuous	Ferric Chloride/ Polymer in Summer
Simcoe WPCP	15.546	Conventional activated sludge, phosphorus removal - continuous, effluent polishing	Ferric Chloride
St. Thomas WPCP	40.914	Conventional activated sludge, phosphorus removal - continuous	Alum
Stratford WPCP	27.276	Conventional activated sludge, phosphorus removal - continuous, effluent polishing	Alum
Tillsonburg WPCP	8.183	Conventional activated sludge, phosphorus removal - continuous	Alum
Wallaceburg WPCP	6.819	Conventional activated sludge, phosphorus removal - continuous	Ferric Chloride
Waterloo WPCP	45.460	Conventional activated sludge, phosphorus removal - continuous	Ferrous Chloride
Little River WPCP (Windsor)	36.368	Conventional activated sludge, phosphorus removal - continuous	Aluminum Chloride
Westerly WPCP (Windsor)	163.656	Conventional activated sludge, phosphorus removal - continuous	Alum
Woodstock WPCP	36.368	Conventional activated sludge, phosphorus removal - continuous	Ferric Chloride

TABLE 3. WPCPs IN THE LAKE ONTARIO/ST. LAWRENCE DRAINAGE BASIN - DESIGN FLOW, PLANT TYPE AND CHEMICALS USED

PLANT	DESIGN FLOW (10^3 m^3/d)	PLANT TYPE	CHEMICAL PRESENTLY USED FOR PHOSPHORUS REMOVAL
Belleville WPCP	29.454	Conventional activated sludge, phosphorus removal - continuous	Ferric/Ferrous Chloride
Brockville WPCP	25.571	Primary, phosphorus removal, continuous	Ferric Chloride
Skyway WPCP (Burlington)	93.193	Conventional activated sludge, phosphorus removal - continuous	Ferric Chloride
Bolton WPCP (Caledon) (up to 1985)	4.546	Conventional activated sludge, phosphorus removal - continuous	No Chemical Used
Campbellford WPCP	5.910	Conventional activated sludge	No Chemicals Used
Cobourg WPCP No.1	16.047	Conventional activated sludge	No Chemicals Used
Cornwall WPCP	37.505	Primary, phosphorus removal - continuous	Alum, Polymer
Dundas WPCP	18.184	Conventional activated sludge, phosphorus removal - continuous, effluent polishing	Alum
Anger Ave. WPCP (Fort Erie)	16.366	Primary, phosphorus removal - continuous	Ferric Chloride
Baker Rd. WPCP (Grimsby)	18.184	Conventional activated sludge, phosphorus removal - continuous	Ferrous Sulphate
Acton WPCP & Lagoon (Halton Hills)	4.546	Conventional activated sludge, phosphorus removal - batch, effluent polishing	Ferric Chloride
Georgetown WPCP (Halton Hills)	13.638	Conventional activated sludge, phosphorus removal - continuous, effluent polishing	Ferric Chloride
Woodward Ave. WPCP (Hamilton)	409.14	Conventional activated sludge	No Chemicals Used
Iroquois WPCP	5.001	Primary, phosphorus removal - continuous	Ferric Chloride
Kingston WPCP	61.371	Primary, phosphorus removal - continuous	Ferric Chloride
Kingston TWP WPCP	25.003	Conventional activated sludge, phosphorus removal - continuous	Alum
Highland Creek WPCP (Metro Toronto)	218.208	Conventional activated sludge, phosphorus removal - continuous	Ferrous Chloride
Humber WPCP (Metro Toronto)	409.140	Conventional activated sludge, phosphorus removal - continuous	Ferrous Chloride
Main WPCP (Metro Toronto)	818.28	Conventional activated sludge, phosphorus removal - continuous	Ferrous Chloride
North Toronto WPCP (Metro Toronto)	45.460	Conventional activated sludge, phosphorus removal - continuous	Ferrous Chloride
Milton WPCP	12.911	Conventional activated sludge, phosphorus removal - continuous, effluent polishing	Alum
Clarkson WPCP (Mississauga)	109.104	Conventional activated sludge, phosphorus removal - continuous	Ferrous Chloride
Lakeview WPCP (Mississauga)	227.300	Conventional activated sludge, phosphorus removal - continuous	Ferrous Chloride
Napanee WPCP	9.092	Conventional activated sludge, phosphorus removal - continuous	Ferrous Chloride
Port Darlington WPCP (Newcastle)	4.546	Conventional activated sludge, phosphorus removal - continuous	Alum
Newmarket WPCP (up to 1984)	13.638	Conventional activated sludge, phosphorus removal - continuous, effluent polishing	-
Stamford WPCP (Niagara Falls)	58.189	Primary, phosphorus removal - continuous	Ferric Chloride
South East WPCP (Oakville)	22.730	Conventional activated sludge, phosphorus removal - continuous	Alum
South West WPCP (Oakville)	47.733	Conventional activated sludge, phosphorus removal - continuous	Ferric Chloride
Orangeville WPCP	7.956	Conventional activated sludge, phosphorus removal - continuous, effluent polishing	Alum
Harmony Cr. WPCP No.1 (Oshawa)	34.095	Trickling filter, phosphorus removal - continuous	Alum
Harmony Cr. WPCP No.2 (Oshawa)	34.095	Conventional activated sludge, phosphorus removal - continuous	Alum
Peterborough WPCP	68.190	Conventional activated sludge, phosphorus removal - continuous	Ferrous Sulphate
York-Durham WPCP (Pickering)	181.84	Conventional activated sludge, phosphorus removal - continuous	Alum
Picton WPCP	4.546	Contact stabilization, phosphorus removal - continuous	Alum
Seaway WPCP (Port Colborne)	15.002	Conventional activated sludge, phosphorus removal - continuous	Ferric Chloride
Port Hope WPCP	9.092	High rate activated sludge, phosphorus removal - continuous	Alum
Prescott-Edwardsburgh WPCP	5.683	Primary, phosphorus removal - continuous	Ferric Chloride/Polymer
Port Dalhousie WPCP (St. Catharines)	61.371	Conventional activated sludge, phosphorus removal - continuous	Ferric Chloride
Port Weller WPCP (St. Catharines)	56.234	Conventional activated sludge, phosphorus removal - continuous	Alum
Trenton WPCP	15.911	Conventional activated sludge, phosphorus removal - continuous	Ferrous Chloride
Welland WPCP	45.460	Conventional activated sludge, phosphorus removal - continuous	Ferrous Chloride
Corbett Cr. WPCP (Whitby)	36.368	Conventional activated sludge, phosphorus removal - continuous	Alum
Pringle Cr. WPCP No.1 (Whitby)	5.683	Conventional activated sludge, phosphorus removal - continuous	Alum
Pringle Cr. WPCP No.2 (Whitby)	9.092	Conventional activated sludge, phosphorus removal - continuous	Alum

TABLE 4. WPCPs IN THE UPPER GREAT LAKES DRAINAGE BASIN - DESIGN FLOW, PLANT TYPE AND CHEMICALS USED FOR PHOSPHORUS REMOVAL

PLANT	DESIGN FLOW (10^3 m^3/d)	PLANT TYPE	CHEMICAL PRESENTLY USED FOR PHOSPHORUS REMOVAL
Barrie WPCP	27.276	Conventional activated sludge, phosphorus removal - continuous	Alum
Bradford WPCP	6.819	Conventional activated sludge, phosphorus removal - continuous, effluent polishing	Alum, Polymer
Collingwood WPCP	24.548	Conventional activated sludge, phosphorus removal - continuous	Alum
Esten Lake WPCP (Elliot Lake)	13.002	Conventional activated sludge, phosphorus removal - continuous, effluent polishing	Alum
Plant Two (Elliot Lake) (up to 1982)	4.546	Primary	-
Goderich WPCP	9.092	Conventional activated sludge, phosphorus removal - continuous	Alum
Hanover WPCP	6.364	Conventional activated sludge, phosphorus removal - continuous	Alum
Huntsville WPCP	4.546	Conventional activated sludge, phosphorus removal - continuous	Alum
Midland WPCP	13.638	Conventional activated sludge, phosphorus removal - continuous	Ferric Chloride
North Bay WPCP	36.368	Conventional activated sludge, phosphorus removal - continuous	Ferric/Ferrous Chloride
Orillia WPCP	18.184	Conventional activated sludge, phosphorus removal - continuous	Alum
Owen Sound WPCP	24.548	Primary	Ferric Chloride
Parry Sound WPCP	6.592	Conventional activated sludge, phosphorus removal - continuous	Ferric Chloride
Port Elgin WPCP	6.455	Oxidation ditch	No Chemicals Used (installed in 1986)
Sault Ste. Marie WPCP	54.552	Primary	No Chemicals Used
Sturgeon Falls WPCP	4.546	Conventional activated sludge, phosphorus removal - continuous	Ferric/Ferrous Chloride (50/50)
Sudbury WPCP	61.371	High rate activated sludge	No Chemicals Used (installed in 1986)
Thunder Bay WPCP	109.104	Primary, phosphorus removal - continuous	Ferric Chloride
Hamner, Val-Caron, Val-Therese WPCP (Valley East)	11.365	Conventional activated sludge, phosphorus removal - continuous	Ferric/Ferrous Chloride
Mikkola WPCP (Walden)	4.546	Extended aeration	No Chemicals Used
Walkerton WPCP	7.546	Conventional activated sludge, phosphorus removal - continuous	Ferric Chloride
Wasaga Beach WPCP	5.773	Extended aeration, effluent polishing, exfiltration	No Chemicals Used

FIGURE 1 — GEOGRAPHIC DISTRIBUTION ONTARIO WATER POLLUTION CONTROL PLANTS IN THE GREAT LAKES DRAINAGE BASIN WITH CAPACITY > 4546 m^3/d (1 mgd)

TABLE 5. SUMMARY OF PLANT PERFORMANCE - LAKE ERIE BASIN

PLANT	DESIGN FLOW (10^3 m^3/d)	1981				1982				1983				1984				1985				LONG TERM AVERAGE (1981-1985)			
		Q	BOD	TSS	TP	Q	BOD	TSS	TP	Q	BOD	TSS	TP	Q	BOD	TSS	TP	Q	BOD	TSS	TP	Q	BOD	TSS	TP
Amherstburg WPCP P	4.546	5.5	70.9	32.0	1.8	5.0	36.1	35.8	2.19	5.0	33.6	25.3	2.90	-	43.9	26.9	4.20	-	25.2	23.9	3.25	5.1	42.7	29.0	2.82
Brantford WPCP	81.828	43.4	15.0	7.6	0.94	49.1	12.4	7.3	0.73	49.3	11.5	5.9	0.75	54.1	12.8	7.4	0.74	58.5	9.5	8.1	0.75	50.9	12.3	7.3	0.78
Galt WPCP (Cambridge)	36.641	29.4	9.1	9.6	0.82	32.1	9.3	10.4	0.76	32.8	20.2	21.3	1.02	31.5	14.1	14.1	0.89	32.0	11.3	11.6	0.80	31.6	12.8	13.4	0.86
Hespeler WPCP (Cambridge)	9.319	5.5	38.0	19.2	0.93	5.3	23.8	14.2	0.71	5.2	23.5	13.9	0.90	5.4	30.7	27.8	0.92	5.5	28.4	30.9	1.27	5.4	28.9	21.2	0.95
Preston WPCP (Cambridge)	16.866	7.7	9.1	9.1	0.76	7.8	11.9	9.0	0.76	8.0	15.4	13.5	0.72	8.0	26.5	15.1	0.57	8.5	17.5	17.2	0.77	8.0	16.1	12.8	0.72
Chatham WPCP	35.913	26.4	8.6	11.0	0.77	23.6	9.0	10.0	0.90	25.2	6.0	12.6	0.70	25.8	5.1	9.5	0.78	29.8	8.3	17.5	1.02	26.2	7.4	12.1	0.83
Dresden WPCP	4.546	1.0	6.8	19.4	0.51	1.2	4.6	10.5	0.40	1.7	3.4	10.7	0.27	2.2	4.7	8.2	0.55	2.4	3.9	8.4	0.33	1.7	4.7	11.5	0.41
Dunnville WPCP	7.728	4.0	33.1	18.9	0.64	4.5	12.6	11.2	0.58	4.5	5.7	8.2	0.50	4.6	25.2	15.7	1.02	4.9	11.9	8.4	0.62	4.5	17.7	12.5	0.67
Fergus WPCP	5.001	3.0	6.9	13.0	0.69	3.3	7.0	15.9	0.64	3.2	9.5	16.6	0.64	3.2	9.5	16.6	0.64	3.9	10.2	24.5	0.55	3.4	8.9	17.4	0.63
Guelph WPCP	54.552	43.3	18.0	16.0	1.20	44.3	24.4	14.5	1.55	44.3	14.0	10.4	1.55	43.6	15.6	11.1	0.96	47.7	7.5	7.7	0.83	44.5	15.9	11.9	1.22
Ingersoll New WPCP	6.819	3.8	9.1	7.6	1.27	4.1	7.1	10.3	1.61	4.0	3.6	6.4	0.33	5.3	8.5	6.6	0.52	4.4	6.9	6.8	0.87	4.3	7.0	7.5	0.91
Kitchener WPCP	122.742	62.3	9.5	9.3	0.80	63.0	6.4	6.9	0.84	66.0	5.6	8.3	0.87	68.6	5.4	6.3	0.69	64.5	7.4	5.2	0.76	64.9	6.9	7.2	0.79
Leamington WPCP	19.093	7.8	16.9	7.9	1.00	7.6	14.8	13.2	0.76	7.2	14.3	11.2	1.00	6.7	7.9	15.7	0.58	6.8	10.9	14.1	0.99	7.2	13.1	12.3	0.87
Adelaide WPCP (London)	18.184	13.6	3.6	4.7	1.00	15.1	3.9	5.2	0.94	14.9	2.4	5.3	0.97	16.8	2.9	5.3	0.93	17.1	2.5	5.3	0.87	15.5	3.1	5.2	0.94
Greenway WPCP (London)	123.33	103.7	4.1	7.4	1.03	123.7	4.0	7.3	1.19	122.4	3.5	6.9	0.99	127.7	4.9	9.3	0.93	132.0	5.2	9.6	0.77	121.9	4.3	8.1	0.98
Oxford WPCP (London)	5.455	3.9	6.9	16.1	2.18	4.7	7.9	16.2	1.68	4.9	5.3	11.6	0.98	5.3	5.4	11.4	0.88	5.4	4.6	7.8	0.74	4.8	6.0	12.6	1.29
Pottersburg WPCP (London)	22.048	13.5	3.4	5.4	0.73	17.3	4.0	5.1	0.70	17.9	2.6	4.8	0.96	17.4	2.9	4.2	0.85	17.4	2.8	3.9	0.63	16.7	3.1	4.6	0.77
Vauxhall WPCP (London)	20.912	19.5	3.6	7.2	0.90	20.2	4.3	6.8	0.85	18.6	3.8	8.8	0.97	18.6	4.8	9.9	0.79	19.6	3.8	8.3	0.63	19.3	4.1	8.2	0.83
Belle River-Maidstone WPCP	6.819	3.8	9.0	10.9	0.40	4.7	8.8	12.2	0.36	5.4	8.0	11.9	0.40	5.0	6.6	11.1	0.62	6.4	4.9	11.0	0.85	5.0	7.5	11.4	0.52
Corunna P.V. Plant (Moore)	4.546	2.1	4.5	11.5	0.93	2.0	5.8	9.2	0.61	1.9	4.5	10.5	0.98	1.4	7.5	8.8	0.87	2.9	9.1	9.6	0.85	2.1	6.4	9.9	0.85
Paris WPCP	7.046	2.1	18.1	27.5	1.86	2.6	22.6	20.4	-	1.9	6.0	9.1	0.90	2.2	8.7	9.5	0.58	2.5	6.2	6.7	0.55	2.3	11.3	14.4	0.93
Sarnia WPCP P	65.917	47.8	41.0	20.0	1.00	47.7	37.0	21.0	1.0	52.3	43.0	18.0	0.88	55.2	44.7	18.8	0.78	54.4	42.6	24.9	0.82	51.5	41.5	20.5	0.90
Simcoe WPCP	15.546	8.4	6.2	3.7	0.36	9.4	6.1	4.2	0.53	9.7	3.2	3.7	0.52	9.4	18.6	15.5	0.79	9.5	3.5	3.4	0.71	9.3	7.6	6.1	0.58
St. Thomas WPCP	40.914	-	9.0	82.6	1.34	15.5	4.8	6.5	1.25	18.3	4.5	4.0	0.81	18.5	11.3	10.9	1.20	18.9	6.4	8.3	1.14	17.8	7.1	22.7	1.15
Stratford WPCP	27.276	23.5	6.8	4.9	0.51	24.7	10.2	4.9	0.60	22.5	11.2	2.9	0.43	22.2	15.6	2.5	0.56	25.0	13.1	1.0	0.23	23.6	11.4	3.3	0.47
Tillsonburg WPCP	8.183	4.7	4.3	7.5	0.60	5.3	2.4	6.4	0.52	5.5	2.7	7.7	0.74	5.3	2.5	6.0	0.40	5.4	3.5	7.6	0.80	5.2	3.1	7.0	0.61
Wallaceburg WPCP	6.819	6.2	6.4	8.4	1.17	5.7	5.2	8.9	0.90	6.1	3.6	5.2	0.33	5.5	8.0	7.1	0.67	8.9	12.2	8.9	0.42	6.5	7.1	7.7	0.72
Waterloo WPCP	45.46	34.9	9.3	7.5	0.73	35.0	11.0	10.9	0.79	39.7	14.2	9.0	0.78	41.6	12.8	10.4	0.98	45.2	6.8	8.9	0.75	39.3	10.8	9.4	0.81
Little R. WPCP (Windsor)	36.368	30.9	3.6	6.6	0.39	30.8	3.4	6.8	0.41	32.3	3.0	8.0	0.43	31.6	4.8	9.9	1.22	45.0	5.3	9.5	0.83	34.1	4.0	8.2	0.65
Westerly WPCP (Windsor) P	163.656	104.1	28.8	24.0	0.92	105.5	26.0	21.6	0.79	105.0	25.0	24.0	0.89	100.7	24.6	20.6	0.73	124.7	22.2	20.0	0.86	108.0	25.3	22.0	0.84
Woodstock WPCP	36.368	19.8	6.0	8.0	0.60	21.5	5.9	16.6	1.03	22.6	8.1	16.1	0.92	21.2	9.5	20.2	0.95	23.9	11.8	16.5	1.02	21.8	8.3	15.5	0.90

P - Primary Plant

TABLE 6. SUMMARY OF PLANT PERFORMANCE - LAKE ONTARIO/ST. LAWRENCE RIVER BASIN

PLANT	DESIGN FLOW (10^3 m^3/d)	1981				1982				1983				1984				1985				LONG TERM AVERAGE (1981-1985)			
		Q	BOD	TSS	TP	Q	BOD	TSS	TP	Q	BOD	TSS	TP	Q	BOD	TSS	TP	Q	BOD	TSS	TP	Q	BOD	TSS	TP
Belleville WPCP	29.454	27.3	16.9	16.2	1.38	28.6	19.6	14.0	1.51	29.5	14.1	16.8	1.09	46.2	34.3	24.5	1.02	40.0	22.5	12.7	0.48	34.3	21.5	16.8	1.09
Brockville WPCP P	25.571	16.0	21.6	19.2	1.63	15.4	22.4	22.0	1.41	15.7	16.2	15.4	1.37	14.7	25.6	21.3	1.01	17.5	22.0	20.9	0.87	15.9	21.5	19.8	1.26
Burlington WPCP	93.193	75.1	7.2	10.1	1.09	77.0	8.0	8.4	0.93	86.6	7.7	6.4	0.54	87.7	9.1	7.1	0.72	67.0	9.3	7.5	0.74	78.3	8.3	7.9	0.80
Bolton WPCP	4.546	3.1	4.1	5.0	0.49	3.8	5.9	4.8	0.28	3.5	3.1	3.5	0.18	3.5	4.9	3.9	0.55	4.1	2.9	4.2	0.47	3.6	4.2	4.3	0.38
Campbellford WPCP X	5.910	6.7	5.3	7.3	0.74	7.4	4.2	6.3	0.63	7.0	4.2	4.8	0.70	7.1	5.5	4.7	0.69	6.8	6.4	5.5	0.86	7.0	5.1	5.7	0.72
Cobourg WPCP No.1 X	16.047	13.8	10.6	10.6	0.75	14.7	9.7	7.6	1.22	14.2	5.0	9.3	0.81	13.0	10.7	11.5	0.66	8.5	14.7	10.9	1.54	13.0	10.1	10.0	0.98
Cornwall WPCP P	37.505	48.6	37.5	52.6	1.67	47.5	47.4	46.9	1.58	49.2	39.2	28.5	0.99	48.5	45.6	23.7	0.98	47.7	40.4	24.5	0.99	48.3	42.0	35.2	1.24
Dundas WPCP	18.184	8.1	5.2	6.1	0.46	9.6	4.9	6.6	0.92	11.8	4.0	3.1	0.60	12.8	8.0	7.6	0.78	13.4	6.6	8.8	0.77	11.1	5.7	6.4	0.71
Anger Ave. WPCP (Fort Erie) P	16.366	17.2	36.0	27.0	0.91	16.9	54.0	22.0	1.05	13.1	25.4	20.0	0.85	12.9	27.7	23.2	0.77	13.0	34.9	28.2	0.75	14.6	35.9	24.1	0.87
Baker Rd. WPCP (Grimsby)	18.184	8.9	11.4	8.4	0.49	10.5	7.0	8.0	0.80	10.7	6.0	5.2	0.86	10.8	6.4	6.9	0.72	13.0	11.7	7.2	0.60	10.6	8.5	7.1	0.69
Acton WPCP & Lagoon (Halton Hills)	4.546	2.6	2.9	8.2	0.97	2.4	2.5	4.3	1.00	2.6	2.3	3.9	0.89	3.4	4.6	4.9	0.55	3.9	2.4	5.7	0.57	3.0	2.9	5.4	0.80
Georgetown WPCP (Halton Hills)	13.638	10.6	3.6	5.0	0.82	9.2	5.5	2.9	0.49	9.3	6.5	4.9	0.66	10.0	13.9	6.0	1.16	11.2	3.6	3.2	0.49	10.0	6.6	4.4	0.73
Woodward Ave. WPCP (Hamilton) X	409.14	264.1	17.4	31.6	2.24	290.0	11.2	17.0	1.15	287.8	15.0	13.0	1.10	323.5	17.9	19.4	1.27	308.3	23.4	19.7	1.31	294.7	17.3	20.1	1.41
Iroquois WPCP P	5.001	3.5	38.0	22.0	3.10	3.5	85.0	54.0	3.00	3.5	93.0	74.0	2.30	3.2	111.9	83.5	2.15	4.1	80.0	79.0	1.90	3.6	80.0	56.7	2.68
Kingston WPCP P	61.371	53.6	22.0	35.0	1.20	60.0	23.0	31.0	1.10	60.1	29.8	25.9	0.91	57.3	25.0	37.1	0.96	66.4	23.7	19.8	0.78	58.7	24.8	30.9	1.01
Kingston TWP WPCP	25.003	16.0	12.5	13.0	1.07	16.6	9.4	7.9	0.92	16.3	11.3	8.6	0.92	15.6	10.9	9.1	0.91	16.4	10.8	8.6	0.89	16.1	11.0	9.5	0.94
Highland Creek WPCP (Metro Toronto)	218.21	153.2	22.6	16.8	1.00	162.3	18.1	11.8	1.04	162.8	19.8	18.0	1.05	156.9	33.9	24.5	0.91	163.3	18.8	16.5	0.77	159.7	22.7	17.5	0.95
Humber WPCP (Metro Toronto)	409.14	406.0	16.4	24.2	1.50	368.7	14.8	18.7	1.24	365.5	14.1	22.5	1.04	339.6	12.7	26.3	1.43	378.1	11.5	18.2	1.08	371.6	13.9	22.0	1.26
Main WPCP (Metro Toronto)	818.28	752.4	17.1	11.7	0.80	709.2	11.6	13.9	0.91	737.6	13.2	11.8	0.89	677.3	19.3	11.9	0.97	683.8	22.3	26.0	1.09	712.0	14.7	15.1	0.93
North Toronto WPCP (Metro Toronto)	45.460	36.4	15.9	20.9	1.00	36.2	18.5	21.8	1.08	35.4	14.5	17.1	1.01	35.8	12.8	7.7	0.85	34.7	15.1	6.8	0.85	35.7	15.4	14.8	0.96
Milton WPCP	12.911	9.5	4.3	5.4	0.50	9.0	4.6	3.3	0.43	9.6	3.7	3.6	0.57	9.9	8.1	2.9	0.36	12.3	2.5	2.6	0.29	10.1	4.6	3.6	0.44
Clarkson WPCP (Mississauga)	109.104	48.1	5.9	10.8	0.81	59.2	7.6	8.7	1.02	67.1	9.1	8.7	1.08	75.3	8.2	8.2	0.89	71.2	11.6	9.5	0.90	64.2	8.5	9.2	0.94
Lakeview WPCP (Mississauga)	227.30	179.0	16.5	15.0	0.78	194.6	19.7	17.2	0.70	190.1	16.1	19.8	0.89	198.8	18.7	18.9	0.85	230.5	16.5	15.7	0.65	198.7	17.5	17.3	0.77
Napanee WPCP	9.092	5.9	30.2	63.5	4.9	6.0	48.4	63.0	8.20	5.4	10.0	19.4	2.20	6.1	7.8	11.8	2.46	7.4	5.8	10.3	1.41	6.2	20.4	33.6	3.83
Port Darlington WPCP (Newcastle)	4.546	-	-	-	-	5.2	18.1	24.1	1.45	6.7	13.5	17.4	1.50	6.4	24.4	17.1	1.83	8.1	13.4	14.1	0.93	6.6	17.2	18.3	1.42
Newmarket WPCP	13.638	13.4	12.8	7.2	0.97	16.5	14.8	5.2	0.63	15.1	10.6	5.6	0.80	14.7	-	-	-	-	-	-	-	14.9	12.7	6.0	0.80
Stamford WPCP (Niagara Falls) P	58.189	44.6	27.0	26.0	1.00	51.9	42.0	26.0	0.80	56.2	50.0	22.0	1.00	56.2	38.0	29.7	0.63	57.1	31.3	23.8	0.46	53.2	37.7	25.5	0.78
South East WPCP (Oakville)	22.730	12.1	2.2	7.1	0.84	11.8	2.7	9.1	0.75	12.4	2.4	5.8	0.96	12.5	3.9	7.3	0.87	-	2.6	8.2	0.86	-	2.8	7.5	0.86
South West WPCP (Oakville)	47.733	30.6	11.8	14.0	1.10	30.0	16.7	14.2	1.37	28.2	10.2	16.3	1.53	24.8	12.3	13.4	0.93	29.0	7.2	15.1	0.91	28.5	11.7	14.6	1.17
Orangeville WPCP	7.956	7.1	4.0	4.9	0.46	8.1	3.1	5.4	0.48	7.4	2.6	3.0	0.31	7.3	6.3	5.3	0.36	8.1	2.5	3.6	0.26	7.6	3.7	4.4	0.37
Harmony Cr. WPCP No.1 (Oshawa)	34.095	25.6	25.0	21.0	1.30	30.9	15.1	16.7	0.90	26.4	*14.4	*18.7	0.89*	25.9	12.8*	18.0*	1.02*	27.1	19.1	17.0*	0.61*	27.2	17.4	18.3	0.94
Harmony Cr. WPCP No.2 (Oshawa)	34.095	27.7	9.5	10.0	0.51	29.6	17.4	14.9	0.87	25.9	*14.4	*18.7	0.89*	26.7	12.8*	18.0*	1.02*	27.2	19.1*	17.0*	0.61*	27.4	14.6	15.6	0.78
Peterborough WPCP	68.190	51.9	8.2	8.6	0.74	54.4	11.7	10.0	0.94	53.1	9.2	7.0	0.77	54.6	12.2	6.0	0.81	56.9	11.9	7.1	0.80	54.1	10.6	7.8	0.81
Duffin Creek WPCP (Pickering)	181.84	41.4	14.9	18.0	0.98	84.5	14.1	12.2	1.75	95.1	22.5	25.2	1.73	121.1	12.8	15.9	0.98	150.0	14.3	15.6	1.05	98.4	15.7	17.4	1.30
Picton WPCP	4.546	3.6	10.4	16.3	1.30	3.6	7.1	13.2	0.75	3.3	7.2	9.3	0.52	3.2	7.3	9.4	0.68	3.1	5.7	8.5	0.50	3.4	7.6	11.4	0.75
Seaway WPCP (Port Colborne)	15.002	11.1	10.4	12.0	0.68	12.9	7.0	15.0	0.70	13.9	11.9	9.7	0.89	14.1	13.2	15.8	1.15	13.2	13.1	15.8	1.13	13.0	11.1	13.7	0.91
Port Hope WPCP	9.092	8.2	4.1	7.0	0.55	6.6	4.0	6.3	1.00	7.4	8.0	4.5	0.57	8.4	5.4	5.7	0.53	9.6	6.0	5.4	0.56	8.0	5.5	5.8	0.64
Prescott-Edwardsburgh WPCP P	5.683	4.7	14.4	26.9	0.67	4.4	17.9	29.8	0.79	4.6	19.8	30.8	0.84	4.5	21.3	31.1	0.88	5.2	17.2	20.3	0.61	4.7	18.1	27.8	0.76
Port Dalhousie WPCP (St. Catharines)	61.371	35.5	9.2	9.9	0.58	36.8	7.0	7.0	0.70	36.4	4.0	6.9	0.53	32.4	7.7	7.5	0.55	41.6	11.5	10.6	0.39	36.5	7.9	8.4	0.55
Port Weller WPCP (St. Catharines)	56.234	38.1	14.7	10.0	0.57	35.6	42.0	26.0	0.80	35.8	9.9	11.8	0.74	35.9	11.9	13.7	0.57	42.1	12.0	13.2	0.78	37.5	18.1	15.0	0.69
Trenton WPCP	15.911	10.9	9.0	7.9	0.71	9.6	15.1	13.0	1.14	9.8	14.1	12.9	0.82	10.8	13.8	11.6	0.58	11.2	10.8	13.0	0.67	10.5	12.6	11.7	0.78
Welland WPCP	45.45	36.9	7.9	10.2	0.71	38.1	11.0	12.0	1.10	41.9	11.1	10.3	0.55	33.9	9.6	10.8	0.36	35.8	11.6	12.1	0.76	35.6	11.5	11.4	0.70
Corbett Cr. WPCP (Whitby)	36.368	15.3	18.2	30.2	2.00	14.9	18.6	39.3	1.70	10.9	13.1	11.5	0.76	10.9	25.0	19.8	0.85	13.5	10.0	13.1	0.59	13.1	16.7	22.8	1.18
Pringle Cr. WPCP No.1 (Whitby)	5.683	4.4	4.0	6.0	0.54	4.3	13.8	12.6	0.62	4.3	5.8	9.8	0.38	6.0	20.2	14.4	0.90	5.5	19.3	14.5	0.70	4.9	12.6	11.5	0.63
Pringle Cr. WPCP No.2 (Whitby)	9.092	6.2	4.2	6.0	0.69	6.1	17.3	27.1	1.27	6.8	6.2	6.5	0.69	6.3	23.1	18.9	1.09	6.5	19.5	14.5	0.94	6.4	14.1	14.6	0.93

P - Primary Plant
X - No Chemicals Used for P Removal
* Combined Effluents

TABLE 7. SUMMARY OF PLANT PERFORMANCE - UPPER GREAT LAKES BASIN

PLANT		DESIGN FLOW (10^3 m^3/d)	1981				1982				1983				1984				1985				LONG TERM AVERAGE (1981-1985)			
			Q	BOD	TSS	TP	Q	BOD	TSS	TP	Q	BOD	TSS	TP	Q	BOD	TSS	TP	Q	BOD	TSS	TP	Q	BOD	TSS	TP
Barrie WPCP		27.276	22.8	10.6	19.1	1.06	21.8	53.0	18.0	0.96	22.7	10.5	16.4	0.94	26.5	8.4	17.7	0.97	26.1	6.8	12.6	0.50	24.0	17.9	16.8	0.89
Bradford WPCP		6.819	3.0	20.3	19.6	0.76	3.4	14.7	12.8	0.42	3.1	6.6	8.7	0.37	3.4	3.0	2.9	0.77	3.1	6.5	6.4	0.42	3.2	10.3	9.9	0.55
Collingwood WPCP		24.548	15.9	70.0	42.0	1.85	15.3	15.0	15.0	0.60	17.1	8.0	10.2	1.65	17.4	7.9	15.3	1.49	18.5	5.8	12.6	1.92	16.8	22.3	19.1	1.50
Esten Lake WPCP (Elliot Lake)		13.002	-	-	-	-	9.7	13.8	11.6	0.77	8.5	12.5	9.8	0.67	10.9	7.9	12.0	1.33	12.5	15.3	15.9	1.10	10.4	12.6	12.4	0.97
Plant Two (Elliot Lake)	P	4.546	4.5	4.3	65.0	5.3	--	--	--	--	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Goderich WPCP P until 1983)		9.092	8.5	10.0	5.0	2.0	7.7	13.0	5.3	2.0	7.1	8.0	7.2	1.50	9.6	6.2	10.0	1.10	11.2	5.5	10.6	0.87	8.8	8.7	7.9	1.49
Hanover WPCP		6.364	3.3	19.4	10.5	2.1	3.7	12.0	13.3	1.0	3.7	8.5	7.5	0.63	3.7	6.9	6.3	0.86	4.3	9.4	7.5	0.87	3.7	11.2	9.2	1.09
Huntsville WPCP		4.546	3.0	6.4	7.6	0.50	4.0	6.3	9.5	0.45	4.0	11.3	13.3	0.38	4.5	6.1	6.7	0.31	4.8	4.4	13.7	0.76	4.0	7.0	9.9	0.45
Midland WPCP (P until 1982)		13.638	8.7	33.2	36.9	11.74	8.4	7.2	4.2	0.46	9.0	8.7	7.3	0.32	9.2	13.9	7.4	0.56	10.9	3.0	6.4	0.57	9.3	13.4	12.6	2.85
North Bay WPCP		36.368	33.3	15.5	19.9	1.38	31.3	22.3	24.1	1.28	32.3	24.5	23.7	1.24	32.6	17.4	24.2	1.50	40.1	22.1	31.4	1.68	33.9	20.5	25.7	1.42
Orillia WPCP		18.184	15.2	12.0	13.8	0.48	17.4	19.0	20.0	0.30	17.5	17.3	8.1	0.31	18.4	18.5	14.8	0.41	19.2	18.4	19.8	0.58	17.6	17.0	15.2	0.41
Owen Sound WPCP	P	24.548	18.1	27.7	26.1	0.82	22.8	24.5	19.8	1.01	19.6	28.8	23.8	1.25	19.6	25.7	25.2	0.84	22.5	23.8	20.4	0.85	20.5	26.1	23.1	0.95
Parry Sound WPCP		6.592	5.2	24.3	38.6	1.14	4.4	6.7	9.3	0.85	4.2	5.2	9.7	0.91	3.4	3.4	8.7	0.86	3.9	6.6	5.7	0.56	4.2	9.3	14.8	0.86
Port Elgin WPCP	X	6.455	3.6	5.4	3.6	2.13	3.5	4.7	2.7	2.4	3.6	2.8	3.6	1.55	3.4	4.0	3.0	1.93	4.1	8.8	2.7	1.56	3.7	5.2	3.1	1.91
Sault Ste. Marie WPCP	XP	54.552	48.3	69.5	54.8	3.15	51.1	67.8	54.6	3.08	46.9	74.1	55.3	4.18	45.9	83.1	61.8	4.61	50.3	83.2	60.0	4.23	48.5	76.4	56.8	3.86
Sturgeon Falls WPCP		4.546	6.7	7.1	6.2	0.70	6.4	5.2	4.8	0.65	6.9	4.8	6.6	0.47	6.8	6.0	5.3	0.33	5.6	4.6	6.0	0.46	6.5	5.6	5.8	0.52
Sudbury WPCP	X	61.371	52.1	11.6	12.7	2.20	51.2	17.3	10.0	1.90	54.9	16.6	13.1	1.49	54.9	10.0	9.4	1.84	52.0	11.9	8.3	2.10	53.0	13.5	10.7	1.91
Thunder Bay WPCP	P	109.104	81.7	53.1	53.6	3.14	96.8	69.6	76.1	3.10	100.5	47.2	43.2	1.61	104.2	51.7	36.1	1.27	113.8	51.4	33.7	1.01	99.4	55.1	48.5	2.03
Hamner, Val-Caron, Val-Therese WPCP (Valley East)		11.365	4.1	15.4	7.1	1.40	4.4	18.1	8.9	1.70	4.8	14.3	4.0	1.48	5.1	14.3	2.8	1.14	5.6	14.3	5.1	0.69	4.8	15.3	5.6	1.29
Mikkola WPCP (Walden)	X	4.546	-	-	-	-	0.5	6.1	20.7	1.7	0.9	11.7	54.5	2.60	1.2	6.2	9.9	2.34	1.2	3.8	4.3	2.66	0.9	7.0	20.1	2.33
Walkerton WPCP		7.546	4.4	19.2	13.7	2.72	5.8	12.9	13.0	0.93	4.9	16.0	13.7	1.33	5.1	16.0	11.7	0.99	5.9	14.0	9.6	0.90	5.2	15.6	12.2	1.38
Wasaga Beach WPCP	X	5.773	-	-	-	-	0.4	--	--	--	0.7	-	-	-	0.8	-	-	-	1.0	-	-	-	0.7	-	-	-

P - Primary Plant
X - No Chemicals Used for P Removal

2.3 Compliance Status

For the purposes of this analysis, compliance was assessed in two ways, namely:

i) Annual Compliance - A plant was considered to be "in compliance" if the annual average effluent concentration of BOD_5, TSS or TP did not exceed the MOE Guidelines for the year being evaluated.

ii) Monthly Compliance - A plant was considered to be "in compliance" if the monthly average effluent concentration of BOD_5, TSS or TP did not exceed the MOE Guidelines for any month in the year being evaluated. (That is, a plant was considered to be out-of-compliance for the year of 1984 if the monthly average effluent concentration exceeded the MOE Guideline during any month in 1984.)

Compliance status was based on the MOE Effluent Criteria for BOD_5, TSS and TP (Policy 0801, revised in 1983), as presented in Table 8. For primary plants, exceedance of the Effluent Design Objectives indicated non-compliance. For secondary plants, exceedance of the Effluent Guidelines indicated non-compliance. For all plants, the effluent phosphorus requirement was considered to be 1 mg/L. Although the compliance status for all plants was determined using the above guidelines, it should be noted that several plants have more stringent site-specific requirements with respect to BOD_5, TSS and/or TP, as shown in Table 9.

Tables 10 to 12 present the annual compliance history (compliance with annual average effluent requirement) for the individual treatment facilities for the years 1981 to 1985 with respect to BOD_5, TSS and TP. In the Lake Erie Basin, sixteen plants (51.6 percent of the 31 plants evaluated) were in compliance on an annual basis with all effluent requirements (BOD_5, TSS and TP) for every year (1981 to 1985). In the Lake Ontario/St. Lawrence River Basin, fifteen plants (34.0 percent of the 44 plants evaluated) were in compliance with all requirements every year, and in the Upper Great Lakes Basin, 4 plants (19.0 percent of 21 plants) were in compliance with all requirements every year. Overall, 35 plants (36.4 percent of 96 plants) met all requirements every year during the 1981 to 1985 period.

TABLE 8. MOE EFFLUENT CRITERIA (POLICY 08-01 and 08-04, 1983)

TREATMENT LEVEL & PROCESS	EFFLUENT DESIGN OBJECTIVES			EFFLUENT GUIDELINES		
	BOD_5	TSS	TP	BOD_5	TSS	TP
A. Primary Treatment						
- Without P-removal	30% Removal	50% Removal				
- With P-removal	50% Removal	70% Removal	- 1.0			1.0
B. Secondary Treatment						
- Conventional A.S.	15	15	1.0	25	25	1.0
- Contact Stabilization	20	20	1.0	25	25	1.0
- Extended Aeration	15	15	1.0	25	25	1.0

TABLE 9. MUNICIPAL WASTEWATER TREATMENT FACILITIES IN THE GREAT LAKES BASIN WITH SITE-SPECIFIC EFFLUENT QUALITY GUIDELINES

PLANT	BOD_5		TSS		TP	
	mg/L	kg/d	mg/L	kg/d	mg/L	kg/d
Lake Erie						
Chatham WPCP	15		15			
Guelph WPCP		440			0.5[1]	
Stratford WPCP					0.5[2]	
Lake Ontario/St. Lawrence						
Belleville WPCP					0.5[2]	
Acton WPCP (Halton Hills)		13.6				
Georgetown WPCP (Halton Hills)		136				
Milton WPCP	4.2		15.0		0.43[3]	
Orangeville WPCP	7.5	60	7.5	60	0.5	4.0
Picton WPCP					0.5[2]	
Trenton WPCP					0.5[2]	
Upper Great Lakes						
Bradford WPCP					0.3	
Goderich WPCP	15	136	15	136		0.9
Hanover WPCP	15		15			

1. River Temp $\leq$ 10°C, TP $\leq$ 1.0 mg/L, >10°C, TP $\leq$ 0.5 mg/L
2. May to October
3. Soluble P

TABLE 10. SUMMARY OF ANNUAL AND LONG-TERM COMPLIANCE FOR BOD, TSS, TP (1981-1985) FOR THE LAKE ERIE DRAINAGE BASIN

PLANT		1981			1982			1983			1984			1985			LONG TERM AVERAGE (1981-1985)		
		BOD	TSS	TP	BOD	TSS	TP	BOD	TSS	TP	BOD	TSS	TP	BOD	TSS	TP	BOD	TSS	TP
Amherstburg WPCP	P	N	N	N	N	N	N	N	N	N	N	N	N	.	.	N	N	N	N
Brantford WPCP		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Galt WPCP (Cambridge)		.	.	.	.	.	.	.	.	N	.	.	.	.	.	.	.	.	.
Hespeler WPCP (Cambridge)		N	.	.	.	.	.	.	.	.	N	N	.	N	N	N	N	.	.
Preston (Cambridge)		.	.	.	.	.	.	.	.	.	N	.	.	.	.	.	.	.	.
Chatham WPCP		.	.	.	.	.	.	.	.	.	.	.	.	N	.	.	.	.	.
Dresden WPCP		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Dunnville WPCP		N	.	.	.	.	.	.	.	.	N	.	N	.	.	.	.	.	.
Fergus WPCP		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Guelph WPCP		.	.	N	.	.	N	.	.	N	.	.	.	.	.	.	.	.	N
Ingersoll New WPCP		.	.	N	.	.	N	.	.	.	.	.	.	.	.	.	.	.	.
Kitchener WPCP		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Leamington WPCP		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Adelaide WPCP (London)		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Greenway WPCP (London)		.	.	N	.	.	N	.	.	.	.	.	.	.	.	.	.	.	.
Oxford WPCP (London)		.	.	N	.	.	N	.	.	.	.	.	.	.	.	.	.	.	N
Pottersburg WPCP (London)		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Vauxhall WPCP (London)		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Belle River-Maidstone WPCP		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Corunna P.V. Plant (Moore)		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Paris WPCP		.	N	N	.	.	-	.	.	.	.	.	.	.	.	.	.	.	.
Sarnia WPCP	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Simcoe WPCP		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
St. Thomas WPCP		.	N	N	.	.	N	.	.	.	.	.	N	.	.	N	.	.	N
Stratford WPCP		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Tillsonburg WPCP		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Wallaceburg WPCP		.	.	N	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Waterloo WPCP		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Little R. WPCP (Windsor)		.	.	.	.	.	.	.	.	.	.	.	N	.	.	.	.	.	.
Westerly WPCP (Windsor)	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Woodstock WPCP		.	.	.	.	.	N	.	.	.	.	.	.	.	.	N	.	.	.

P - Primary Plant
X - No Chemicals Used for P Removal
N - Not in Compliance
. - In Compliance
- - No Data

* Compliance Based on MOE 1983 Effluent Criteria (Table 8).

TABLE 11. SUMMARY OF ANNUAL AND LONG-TERM COMPLIANCE FOR BOD, TSS, TP (1981-1985) FOR THE LAKE ONTARIO/ST. LAWRENCE DRAINAGE BASIN

PLANT		1981			1982			1983			1984			1985			LONG TERM AVERAGE (1981-1985)		
		BOD	TSS	TP	BOD	TSS	TP	BOD	TSS	TP	BOD	TSS	TP	BOD	TSS	TP	BOD	TSS	TP
Belleville WPCP		.	.	N	.	.	N	.	.	N	N	.	N	.	.	.	.	.	N
Brockville WPCP	P	.	.	N	.	.	N	.	.	N	.	.	N	.	.	.	.	.	N
Skyway WPCP (Burlington)		.	.	N	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bolton WPCP (Caledon)		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Campbellford WPCP	X	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Cobourg WPCP No. 1	X	.	.	.	.	.	N	.	.	.	.	.	.	.	.	N	.	.	.
Cornwall WPCP	P	N	.	N	N	N	N	N	N	.	N	.	.	N	.	.	N	N	N
Dundas WPCP		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Anger Ave. WPCP (Fort Erie)	P	.	N	.	N	.	N	.	.	.	.	.	.	.	N	.	.	.	.
Baker Rd. WPCP (Grimsby)		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Acton WPCP & Lagoon (Halton Hills)		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Georgetown WPCP (Halton Hills)		.	.	.	.	.	.	.	.	.	.	.	N	.	.	.	.	.	.
Woodward Ave. WPCP (Hamilton)	X	.	N	N	.	.	N	.	.	N	.	.	N	.	.	N	.	.	N
Iroquois WPCP	P	.	N	N	N	N	N	N	N	N	N	N	N	-	-	N	N	N	N
Kingston WPCP	P	.	.	N	.	.	N	.	.	.	.	.	.	.	.	.	.	.	N
Kingston TWP WPCP		.	.	N	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Highland Creek WPCP (Metro Toronto)		.	.	.	.	.	N	.	.	N	N	.	.	.	.	.	.	.	.
Humber WPCP (Metro Toronto)		.	.	N	.	.	N	.	.	N	.	N	N	.	.	N	.	.	N
Main WPCP (Metro Toronto)		.	.	.	.	.	.	.	.	.	.	.	.	.	N	N	.	.	.
North Toronto WPCP (Metro Toronto)		.	.	.	.	.	N	.	.	N	.	.	.	.	.	.	.	.	.
Milton WPCP		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Clarkson WPCP (Mississauga)		.	.	.	.	.	N	.	.	N	.	.	.	.	.	.	.	.	.
Lakeview WPCP (Mississauga)		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Napanee WPCP		N	N	N	N	N	N	.	.	N	.	.	N	.	.	N	.	N	N
Port Darlington WPCP (Newcastle)		-	-	-	.	.	N	.	.	N	.	.	N	.	.	.	.	.	N
Newmarket WPCP		.	.	.	.	.	.	.	.	.	-	-	-	-	-	-	.	.	.
Stamford WPCP (Niagara Falls)	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
South East WPCP (Oakville)		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
South West WPCP (Oakville)		.	.	N	.	.	N	.	.	N	.	.	.	.	.	.	.	.	N
Orangeville WPCP		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Harmony Cr. WPCP No. 1 (Oshawa)		.	.	N	.	.	.	.	.	.	.	.	N	.	.	.	.	.	.
Harmony Cr. WPCP No. 2 (Oshawa)		.	.	.	.	.	.	.	.	.	.	.	N	.	.	.	.	.	.
Peterborough WPCP		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Duffin Creek WPCP (Pickering)		.	.	.	.	.	N	.	N	N	.	.	.	.	.	N	.	.	N
Picton WPCP		.	.	N	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Seaway WPCP (Port Colborne)		.	.	.	.	.	.	.	.	.	.	.	N	.	.	N	.	.	.
Port Hope WPCP		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Prescott-Edwardsburg WPCP	P	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Port Dalhousie WPCP (St. Catharines)		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Port Weller WPCP (St. Catharines)		.	.	.	N	N	.	.	.	.	.	.	.	.	.	.	.	.	.
Trenton WPCP		.	.	.	.	.	N	.	.	.	.	.	.	.	.	.	.	.	.
Welland WPCP		.	.	.	.	.	N	.	.	.	.	.	.	.	.	.	.	.	.
Corbett Cr. WPCP (Whitby)		.	N	N	.	N	N	.	.	.	.	.	.	.	.	.	.	.	N
Pringle Cr. WPCP No. 1 (Whitby)		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Pringle Cr. WPCP No .2 (Whitby)		.	.	.	.	N	N	.	.	.	.	.	N	.	.	.	.	.	.

P - Primary Plant

X - No Chemicals Used for P Removal

N - Not in Compliance

. - In Compliance

- - No data

* Compliance Based on MOE 1983 Effluent Criteria (Table 8).

TABLE 12. SUMMARY OF ANNUAL AND LONG-TERM COMPLIANCE FOR BOD, TSS, TP (1981-1985) FOR THE UPPER GREAT LAKES DRAINAGE BASIN

PLANT		1981			1982			1983			1984			1985			LONG TERM AVERAGE (1981-1985)		
		BOD	TSS	TP	BOD	TSS	TP	BOD	TSS	TP	BOD	TSS	TP	BOD	TSS	TP	BOD	TSS	TP
Barrie WPCP		.	.	N	N	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Bradford WPCP		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Collingwood WPCP		N	N	N	.	.	.	.	.	N	.	.	N	.	.	N	.	.	N
Esten Lake WPCP (Elliot Lake)		-	-	-	.	.	.	.	.	.	.	.	N	.	.	N	.	.	.
Goderich WPCP	P (until 1983)	.	.	N	.	.	N	.	.	N	.	.	N	.	.	.	.	.	N
Hanover WPCP		.	.	N	.	.	.	.	.	.	.	.	.	.	.	.	.	.	N
Huntsville WPCP		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Midland WPCP		N	N	N	.	.	.	.	.	.	.	.	.	.	.	.	.	.	N
North Bay WPCP		.	.	N	.	N	N	.	N	N	.	.	N	.	N	N	.	N	N
Orillia WPCP		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Owen Sound WPCP	P	.	.	.	.	.	N*	.	.	N	.	.	.	.	.	.	.	.	.
Parry Sound WPCP		.	N	N	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Port Elgin WPCP	X	.	.	N	.	.	N	.	.	N	.	.	N	.	.	N	.	.	N
Sault Ste. Marie WPCP	XP	.	.	N	.	.	N	.	.	N	.	.	N	.	.	N	.	.	N
Sturgeon Falls WPCP		.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.	.
Sudbury WPCP	X	.	.	N	.	.	N	.	.	N	.	.	N	.	.	N	.	.	N
Thunder Bay WPCP	P	.	.	N	.	.	N	.	.	N	.	.	N	.	.	N	.	.	N
Hamner, Val-Caron, Val-Therese WPCP (Valley East)		.	.	N	.	.	N	.	.	N	.	.	N	.	.	.	.	.	N
Mikkola WPCP (Walden)	X	-	-	-	.	.	N	.	N	N	.	.	N	.	.	N	.	.	N
Walkerton WPCP		.	.	N	.	.	.	.	.	N	.	.	.	.	.	.	.	.	N
Wasaga Beach WPCP	X	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

P - Primary Plant
X - No Chemicals Used for P Removal
N - Not in Compliance
. - In Compliance
- - No data

* Compliance Based on MOE 1983 Effluent Criteria (Table 8).

Figure 2 illustrates the number of plants that were not in compliance with respect to annual average BOD_5, TSS and TP effluent concentrations for the 5 year period. These data indicated a decreasing trend in the number of plants that were not in compliance from 1981 to 1985 for all parameters. It should also be noted that there were a significantly greater number of plants that exceeded effluent TP limits compared to those that exceeded BOD_5 and TSS effluent limits.

Tables 13 to 15 summarize the compliance status for BOD_5, TSS and TP for the years 1984 and 1985 when compliance is assessed on a monthly basis, along with the compliance status on the basis of annual average effluent concentration. It should again be noted that plants were not attempting to meet a monthly compliance requirement during these years. From these data, summaries presenting the number of plants that were in compliance on an annual average basis compared to the number of plants that would be in compliance on a monthly average basis were developed and are presented in Table 16 and Figures 3 to 5. It can be observed that there are significantly fewer plants in compliance when evaluated on a monthly average basis for all parameters. The largest difference was consistently for TP, with up to 50 percent (1984 total, Table 15) more plants being in compliance when evaluated on an annual average than on a monthly average basis. In the Lake Erie Basin, only one plant (Kitchener WPCP) would be in compliance with the BOD_5, TSS and TP effluent requirements for both 1984 and 1985 if compliance was assessed on a monthly average basis. In the Lake Ontario/St. Lawrence River Basin, only three plants (Milton, Orangeville and Port Hope) would be in compliance with all requirements for both years based on monthly average effluent concentration. In the Upper Great Lakes Basin, two plants (Bradford and Sturgeon Falls) would be in this compliance category. Overall, 7 plants (6.3 percent of the total) were in compliance with all effluent quality requirements (BOD_5, TSS, TP) for all months of 1984 and 1985. Of these seven plants, three (Milton, Orangeville and Brantford) have more stringent, site-specific discharge limits on phosphorus.

Figures 6 to 8 illustrate the number of months during 1984 and 1985 that plants exceeded the effluent requirements for BOD_5, TSS and TP, respectively. Approximately two-thirds of the 96 plants evaluated were consistently in compliance with the BOD_5 and TSS requirements (zero months out-of-compliance) in 1984 and 1985. Of those that were out-of-compliance, the

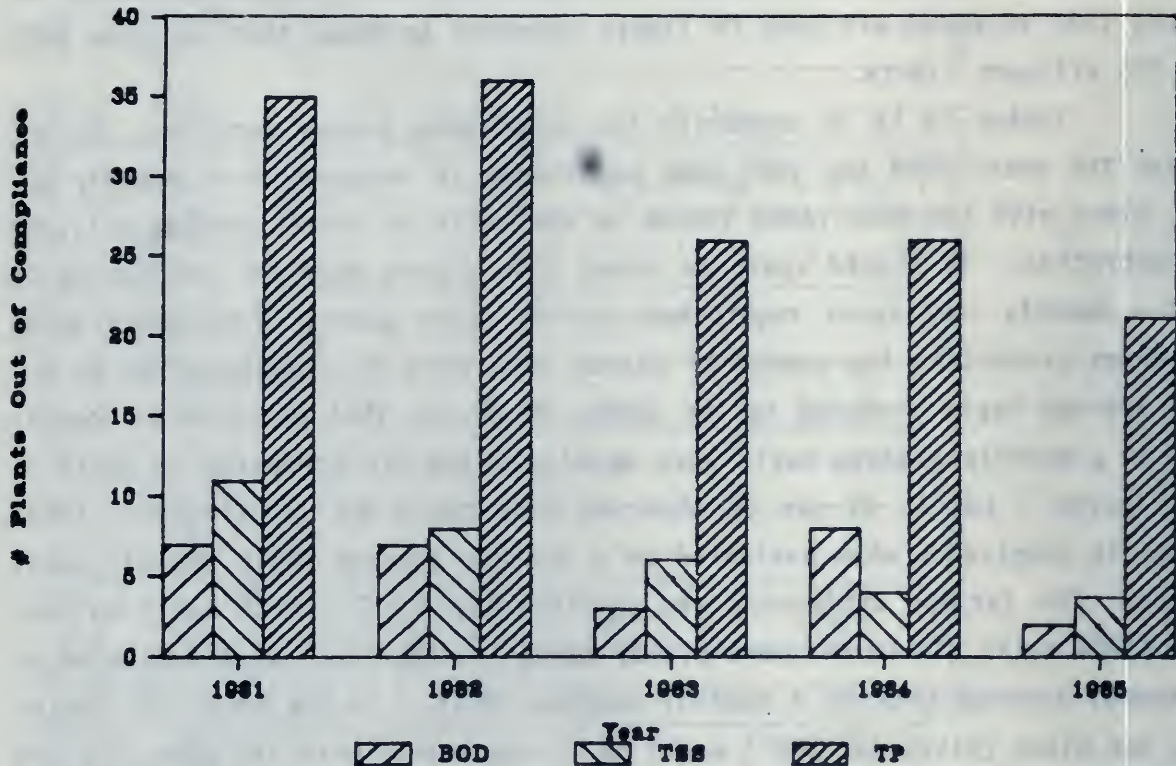

FIGURE 2 - ANNUAL COMPLIANCE SUMMARY FOR 96 PLANTS IN ONTARIO

TABLE 13. SUMMARY OF ANNUAL AND MONTHLY COMPLIANCE* FOR LAKE ERIE DRAINAGE BASIN (1984 & 1985)

PLANT	1984						1985					
	ANNUAL COMPLIANCE			MONTHLY COMPLIANCE (Mo's in Compliance)			ANNUAL COMPLIANCE			MONTHLY COMPLIANCE (Mo's in Compliance)		
	BOD	TSS	TP	BOD	TSS	TP	BOD	TSS	TP	BOD	TSS	TP
Amherstburg WPCP P	N	N	N	3/10	3/10	0/10	.	.	N	4/11	5/10	2
Brantford WPCP	.	.	.	.	.	.	.	.	.	.	.	11
Galt WPCP (Cambridge)	.	.	.	10/11	10	10	.	.	.	.	.	.
Hespeler WPCP (Cambridge)	N	N	.	4	6	8	N	N	N	5	5	5
Preston WPCP (Cambridge)	N	.	.	7	11	.	.	.	.	9	10	9/11
Chatham WPCP	.	.	.	.	.	.	.	.	N	.	9	7
Dresden WPCP	.	.	.	.	.	9	.	.	.	.	.	.
Dunnville WPCP	N	.	N	10	10	9	.	.	.	11	.	.
Fergus WPCP	.	.	.	.	9	.	.	.	.	.	7	.
Guelph WPCP	.	.	.	11	.	6	.	.	.	.	.	10
Ingersoll New WPCP	.	.	.	.	.	10	.	.	.	.	.	9
Kitchener WPCP	.	.	.	.	.	.	.	.	.	.	.	.
Leamington WPCP	.	.	.	.	9/10	8/10	.	.	.	11	10	8
Adelaide WPCP (London)	.	.	.	.	.	10	.	.	.	.	.	.
Greenway WPCP (London)	.	.	.	.	.	8	.	.	.	.	.	10
Oxford WPCP (London)	.	.	.	.	.	9	.	.	.	.	.	.
Pottersburg WPCP (London)	.	.	.	.	.	.	.	.	.	.	.	11
Vauxhall WPCP (London)	.	.	.	.	.	11	.	.	.	.	.	11
Belle-River - Maidstone WPCP	.	.	.	.	.	10	.	.	.	.	.	9
Corunna P.V. Plant (Moore)	.	.	.	.	.	5	.	.	.	.	.	7
Paris WPCP	.	.	.	11	.	.	.	.	.	11	.	11
Sarnia WPCP P	.	.	.	9/10	.	.	.	.	.	.	.	11
Simcoe WPCP	.	.	.	10	10	11	.	.	.	.	.	.
St. Thomas WPCP	.	.	N	10/11	10/11	5/11	.	.	N	.	11	7
Stratford WPCP	.	.	.	11	.	.	.	.	.	11	.	.
Tillsonburg WPCP	.	.	.	.	.	.	.	.	.	.	.	11
Wallaceburg WPCP	.	.	.	.	.	10	.	.	.	11	.	8/9
Waterloo WPCP	.	.	.	10	.	8	.	.	.	.	.	11
Little River WPCP (Windsor)	.	.	N	.	.	7	.	.	.	.	.	9
Westerly WPCP (Windsor) P	.	.	.	.	.	11	.	.	.	.	.	10
Woodstock WPCP	.	.	.	.	.	10	.	.	N	.	.	6/11

P - Primary Plant
X - No Chemicals Used for P Removal
N - Not in Compliance
. - In Compliance

* Compliance based on MOE 1983 Effluent Criteria (Table 8).

TABLE 14. SUMMARY OF ANNUAL AND MONTHLY COMPLIANCE* FOR LAKE ONTARIO DRAINAGE BASIN (1984 & 1985)

PLANT	1984						1985					
	ANNUAL COMPLIANCE			MONTHLY COMPLIANCE (Mo's in Compliance)			ANNUAL COMPLIANCE			MONTHLY COMPLIANCE (Mo's in Compliance)		
	BOD	TSS	TP	BOD	TSS	TP	BOD	TSS	TP	BOD	TSS	TP
Belleville WPCP	N	.	N	7	8	8	.	.	.	8	.	.
Brockville WPCP P	.	.	N	11	.	6	.	.	.	.	.	9
Burlington WPCP	.	.	.	.	.	11	.	.	.	.	.	11
Bolton WPCP	.	.	.	.	.	.	.	.	.	.	.	9/10
Campbellford WPCP X	.	.	.	.	.	10/11	.	.	.	.	.	8/11
Cobourg WPCP No.1 X	.	.	.	.	.	10	.	.	N	10/11	.	7/10
Cornwall WPCP P	N	.	.	9	10	8	N	.	.	4	11	6
Dundas WPCP	.	.	.	.	.	8	.	.	.	.	11	9
Anger Ave. WPCP (Fort Erie) P	.	.	.	9/10	5/10	8/10	.	N	.	9	6	10
Baker Rd. WPCP (Grimsby)	.	.	.	.	.	10/11	.	.	.	11	.	.
Acton WPCP + Lagoon (Halton Hills)	.	.	.	.	.	10	.	.	.	.	.	11
Georgetown WPCP (Halton Hills)	.	.	N	11	.	7	.	.	.	.	.	.
Woodward Ave. WPCP (Hamilton) X	.	.	N	10	9	4	.	.	N	7	9	3
Iroquois WPCP P	N	N	N	1/9	0/9	2/8	-	-	N	-	-	-
Kingston WPCP P	.	.	.	9	10	8	.	.	.	.	11	10
Kingston Twp. WPCP	.	.	.	.	.	10	.	.	.	4/6	4/6	.
Highland Cr. WPCP (Metro Toronto)	N	.	.	2	7	10	.	.	.	11	11	.
Humber WPCP (Metro Toronto)	.	N	N	.	8	2	.	.	N	.	10	6
Main WPCP (Metro Toronto)	.	.	.	9	.	8	.	N	N	8	7	5
North Toronto WPCP (Metro Toronto)	.	.	.	.	.	9	.	.	.	11	.	10
Milton WPCP	.	.	.	.	.	.	.	.	.	.	.	.
Clarkson WPCP (Mississauga)	.	.	.	.	.	11	.	.	.	.	.	10
Lakeview WPCP (Mississauga)	.	.	.	.	11	10	.	.	.	.	10	.
Napanee WPCP	.	.	N	.	11	1	.	.	N	.	.	3
Port Darlington (Newcastle)	.	.	N	7/10	8/10	4/10	.	.	.	.	.	8/11
Stamford WPCP (Niagara Falls) P	.	.	.	7	.	11	.	.	.	11	11	.
South East WPCP (Oakville)	.	.	.	.	.	8	.	.	.	.	.	8/11
South West WPCP (Oakville)	.	.	.	.	.	8	.	.	.	.	9/11	8/11
Orangeville WPCP	.	.	.	.	.	.	.	.	.	.	.	.
Harmony Cr. WPCP No.1 (Oshawa)	.	.	N	.	.	6	.	.	.	5/6	4/6	5/6
Harmony Cr. WPCP No.2 (Oshawa)	.	.	N	.	.	6	.	.	.	5/6	.	.
Peterborough WPCP	.	.	.	11	.	8/11	.	.	.	.	.	8/11
Duffin Creek WPCP (Pickering)	.	.	.	.	1	8	.	.	N	.	.	7
Picton WPCP	.	.	.	.	1	11	.	.	.	.	.	10/11
Seaway WPCP (Port Colborne)	.	.	N	11	10	5	.	.	N	.	11	6
Port Hope WPCP	.	.	.	.	.	.	.	.	.	.	.	.
Prescott-Edwardsburgh WPCP P	.	.	.	8	10	11	.	.	.	.	11	.
Port Dalhousie WPCP (St. Catharines)	.	.	.	.	.	.	.	.	.	11	.	.
Port Weller WPCP (St. Catharines)	.	.	.	11	.	.	.	.	.	.	11	10
Trenton WPCP	.	.	.	.	.	11	.	.	.	.	11	.
Welland WPCP	.	.	.	11	.	.	.	.	.	.	.	10
Corbett Cr. WPCP (Whitby)	.	.	.	8/10	9	9	.	.	.	11	.	.
Pringle Cr. WPCP No.1 (Whitby)	.	.	.	9	10	9	.	.	.	10	10	10
Pringle Cr. WPCP No.2 (Whitby)	.	.	N	10	9	7/11	.	.	.	9	9	7

P - Primary Plant
X - No Chemicals Used for P Removal
N - Not in Compliance
. - In Compliance
- - No data

* Compliance based on MOE 1983 Effluent Criteria (Table 8).

TABLE 15. SUMMARY OF ANNUAL AND MONTHLY COMPLIANCE* FOR UPPER GREAT LAKES DRAINAGE BASIN (1984 & 1985)

PLANT		1984						1985					
		ANNUAL COMPLIANCE			MONTHLY COMPLIANCE (Mo's in Compliance)			ANNUAL COMPLIANCE			MONTHLY COMPLIANCE (Mo's in Compliance)		
		BOD	TSS	TP	BOD	TSS	TP	BOD	TSS	TP	BOD	TSS	TP
Barrie WPCP		.	.	.	.	.	8	.	.	.	.	.	.
Bradford WPCP		.	.	.	.	.	.	.	.	.	.	.	.
Collingwood WPCP		.	.	N	.	10/11	3/11	.	.	N	.	11	2
Esten Lake WPCP (Elliot Lake)		.	.	N	.	.	6	.	.	N	10	.	5
Goderich WPCP		.	.	N	.	.	4	.	.	.	.	.	9
Hanover WPCP		.	.	.	.	.	8	.	.	.	11	.	9
Huntsville WPCP		.	.	.	.	.	.	.	.	.	.	.	5/7
Midland WPCP		.	.	.	10/11	.	10/11	.	.	.	.	.	.
North Bay WPCP		.	.	N	10	7	2	.	N	N	9	3	0
Orillia WPCP		.	.	.	8/11	.	.	.	.	.	9	9	9
Owen Sound WPCP	P	.	.	.	9	.	10	.	.	.	.	.	9
Parry Sound WPCP		.	.	.	.	.	8	.	.	.	.	.	.
Port Elgin WPCP	X	.	.	N	.	.	1	.	.	N	.	.	1
Sault Ste. Marie WPCP	XP	.	.	N	.	.	0	.	.	N	.	.	0
Sturgeon Falls WPCP		.	.	.	.	.	.	.	.	.	.	.	.
Sudbury WPCP		.	.	N	.	.	0	.	.	N	11	.	0
Thunder Bay WPCP	P	.	.	N	11	6	2	.	.	N	.	.	8
Hamner, Val-Caron, Val-Therese WPCP (Valley East)		.	.	N	10	.	7	.	.	.	10	.	.
Mikkola WPCP (Walden)	X	.	.	N	.	10	0	.	.	N	.	.	0
Walkerton WPCP		.	.	.	9	.	8	.	.	.	10	.	7
Wasaga Beach WPCP	X	-	-	-	-	-	-	-	-	-	-	-	-

P - Primary Plant
X - No Chemicals Used for P Removal
N - Not in Compliance
. - In Compliance
- - No data

* Compliance based on MOE 1983 Effluent Criteria (Table 8).

TABLE 16. NUMBER OF PLANTS IN ANNUAL AND MONTHLY COMPLIANCE WITH BOD_5/TSS/TP REQUIREMENTS FOR 1984 AND 1985

BASIN	TOTAL NUMBER OF PLANTS	1984						1985					
		IN COMPLIANCE ANNUALLY*			IN COMPLIANCE MONTHLY*			IN COMPLIANCE ANNUALLY*			IN COMPLIANCE MONTHLY*		
		BOD_5	TSS	TP	BOD_5	TSS	TP	BOD_5	TSS	TP	BOD_5	TSS	TP
Lake Erie	31 (100%)	27 (87.1%)	29 (93.5%)	27 (87.1%)	19 (61.3%)	22 (71.0%)	10 (32.3%)	30 (96.8%)	30 (96.8%)	26 (83.8%)	23 (74.2%)	24 (77.4%)	9 (29.0%)
Lake Ontario & St. Lawrence	44 (100%)	40 (90.9%)	42 (95.5%)	32 (72.9%)	24 (54.5%)	26 (59.1%)	7 (15.9%)	43 (97.7%)	42 (95.5%)	36 (81.8%)	26 (59.1%)	24 (54.4%)	15 (34.1%)
Upper Great Lakes	21 (100%)	20 (95.2%)	20 (95.2%)	10 (47.6%)	13 (61.9%)	16 (76.2%)	4 (19.0%)	20 (95.2%)	19 (90.5%)	12 (57.1%)	13 (61.9%)	17 (81.0%)	6 (28.6%)
TOTAL	96 (100%)	87 (90.6%)	90 (93.8%)	69 (71.9%)	57 (59.4%)	64 (66.7%)	21 (21.9%)	93 (96.9%)	92 (95.8%)	74 (78.7%)	62 (64.6%)	65 (67.7%)	30 (31.3%)

* Compliance based on MOE 1983 Effluent Criteria (Table 8).

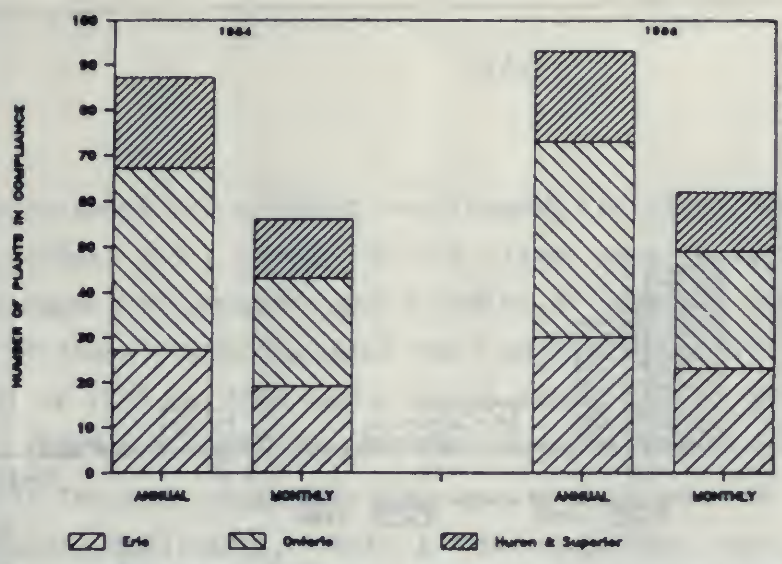

FIGURE 3 - COMPARISON OF BOD_5 COMPLIANCE STATUS BASED ON ANNUAL AND MONTHLY ASSESSMENT FOR 1984 AND 1985

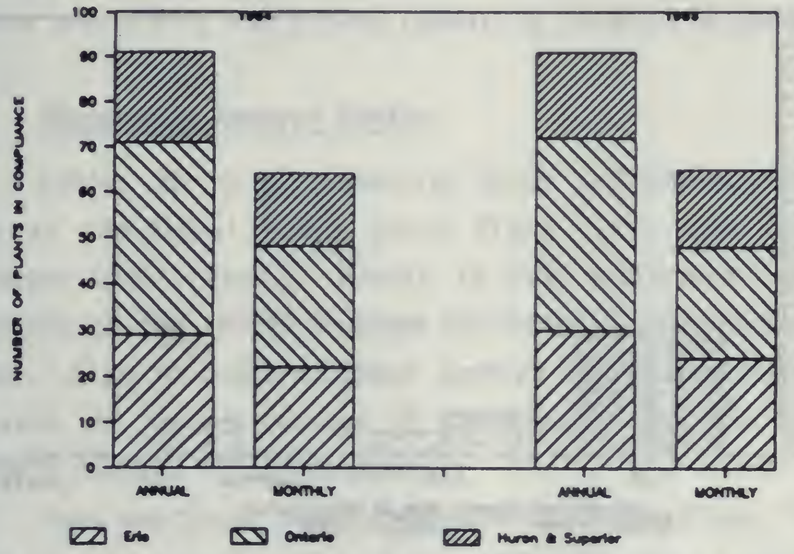

FIGURE 4 - COMPARISON OF TSS COMPLIANCE STATUS BASED ON ANNUAL AND MONTHLY ASSESSMENT FOR 1984 AND 2985

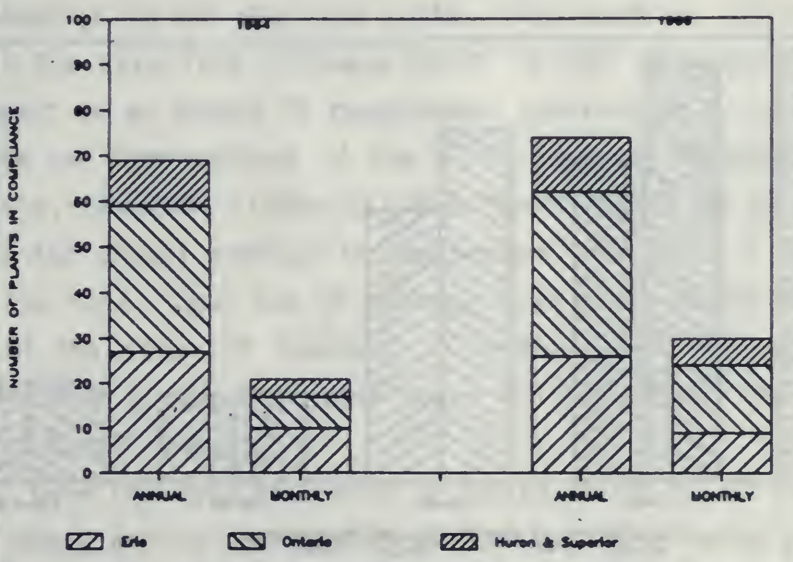

FIGURE 5 - COMPARISON OF TP COMPLIANCE STATUS BASED ON ANNUAL AND MONTHLY ASSESSMENT FOR 1984 AND 1985

FIGURE 6 - MONTHLY BOD_5 COMPLIANCE FOR 96 PLANTS IN ONTARIO

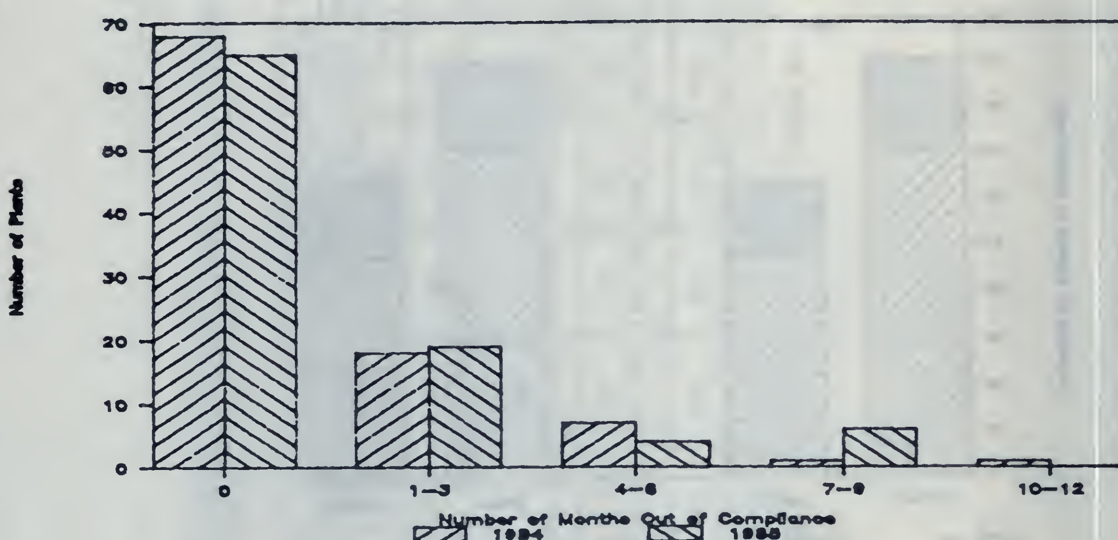

FIGURE 7 - MONTHLY TSS COMPLIANCE FOR 96 PLANTS IN ONTARIO

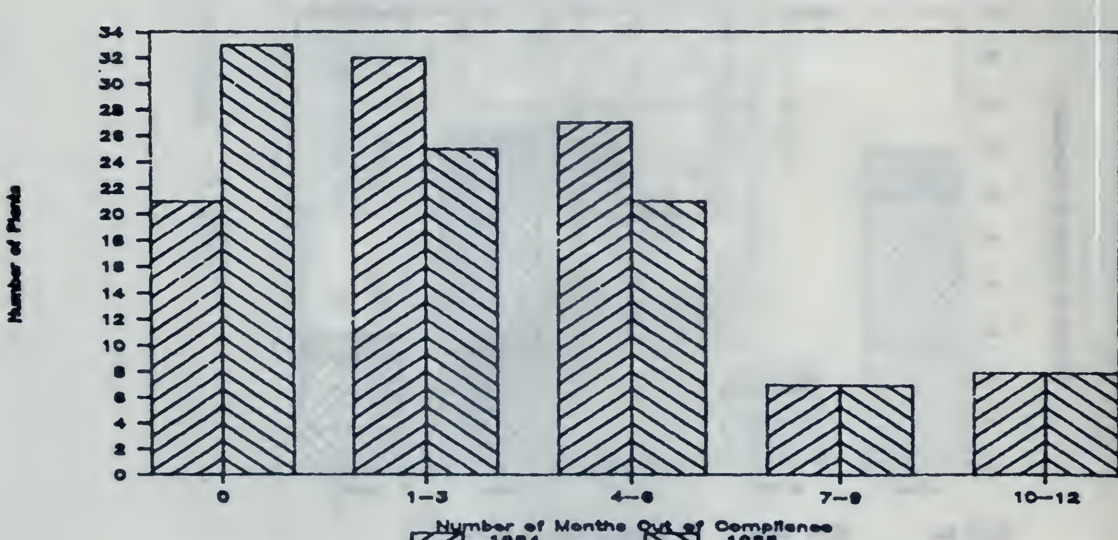

FIGURE 8 - MONTHLY TP COMPLIANCE FOR 96 PLANTS IN ONTARIO

majority exceeded the effluent requirement for three months or less. Conversely, almost fifty percent of the plants were out-of-compliance with the TP requirement for between 1 and 6 months of 1984 and 1985 and more than ten percent of these plants exceeded the 1 mg/L effluent TP requirement for more than half of 1984 and 1985 (more than 6 months of each year).

Tables 17 to 19 present the average effluent concentration of BOD_5, TSS and TP for each plant for those months that were not in compliance with the effluent requirement. With a few exceptions, the average effluent TP concentration during months not in compliance with the 1 mg/L requirement was in the range of 1.0 to 1.5 mg/L. Exceptions were generally primary treatment facilities and plants not adding chemicals to achieve phosphorus removal.

2.4 Phosphorus Removal Status

Tables 20 to 25 summarize plant performance status for 1984 and 1985 on an individual basin basis (Lake Erie, Lake Ontario/St. Lawrence River, Upper Great Lakes). Plants in each basin have been grouped in categories based on the annual average effluent TP concentration achieved during each year. Also included in these summary tables are the plants that did not comply with the annual average TP requirement and those that complied with the monthly average TP requirement.

From the plant status summaries, basin flows, loadings and aggregate average TP concentrations for each status group were calculated. These values show the contribution from each status group to the flows and phosphorus loadings to the drainage basin. For example, Table 20 shows that the plants in the Lake Erie drainage basin in 1984 that were not in compliance with respect to an annual TP requirement contributed 7.7 percent of the total basin flow and 12.8 percent of the total basin TP loading. In the Lake Ontario Basin, the 1984 (Table 22) flow contribution of plants not in compliance with the annual average TP requirement was 822.5 x 10^3 m^3/d (30.8 percent of the total) and the TP loading from these plants was 1080 kg/d (40.2 percent of the total TP loading). In the Upper Great Lakes Basin, these plants in 1984 (Table 24) contributed 64 percent of the basin flow and 86 percent of the TP loading.

From the data presented in Tables 20 to 25, it is apparent that the overall impact on the total basin TP loading of bringing plants into compliance with the 1 mg/L effluent requirement is more strongly influenced by the

TABLE 17. LAKE ERIE NON-COMPLIANCE AVERAGES FOR 1984 & 1985

PLANT		BOD$_5$			TSS			TP		
		# MO's DATA	# MO's O of C	AVERAGE FOR MO's O of C	# MO's DATA	# MO's O of C	AVERAGE FOR MO's O of C	# MO's DATA	# MO's O of C	AVERAGE FOR MO's O of C
Amherstburg WPCP	P	21	14	-	20	12	-	22	20	3.98
Brantford WPCP		24	0	-	24	0	-	24	1	1.05
Galt WPCP (Cambridge)		23	1	26.3	24	2	27.4	24	2	1.04
Hespeler WPCP (Cambridge)		24	15	35.8	24	13	37.7	24	11	1.55
Preston WPCP (Cambridge)		24	8	35.4	24	3	48.7	23	2	1.50
Chatham WPCP		24	0	-	24	3	28.3	24	5	1.36
Dresden WPCP		24	0	-	24	0	-	24	3	1.37
Dunnville WPCP		24	3	99.8	24	2	47.3	24	3	2.53
Fergus WPCP		24	0	-	24	8	30.0	24	0	-
Guelph WPCP		24	1	26.8	24	0	-	24	8	1.20
Ingersoll New WPCP		24	0	-	24	0	-	24	5	1.53
Kitchener WPCP		24	0	-	24	0	-	24	0	-
Leamington WPCP		22	1	44.8	22	3	43.9	22	6	1.47
Adelaide WPCP (London)		24	0	-	24	0	-	24	2	1.10
Greenway WPCP (London)		24	0	-	24	0	-	24	6	1.22
Oxford WPCP (London)		24	0	-	24	0	-	24	3	1.30
Pottersburg WPCP (London)		24	0	-	24	0	-	24	1	1.10
Vauxhall WPCP (London)		24	0	-	24	0	-	24	2	1.15
Belle River - Maidstone WPCP		24	0	-	24	0	-	24	5	1.21
Corunna P.V. Plant (Moore)		24	0	-	24	1	27.4	24	12	1.29
Paris WPCP		24	2	26.4	24	0	-	24	1	1.13
Sarnia WPCP	P	21	1	-	24	0	-	23	1	1.52
Simcoe WPCP		24	2	93.8	24	2	79.8	24	1	1.38
St. Thomas WPCP		23	1	39.7	23	2	40.0	23	11	1.55
Stratford WPCP		24	2	26.9	24	0	-	24	0	-
Tillsonburg WPCP		24	0	-	24	0	-	24	1	1.45
Wallaceburg WPCP		24	1	27.0	23	0	-	21	3	1.23
Waterloo WPCP		24	2	31.5	24	0	-	24	5	1.34
Little River WPCP (Windsor)		24	0	-	24	0	-	24	8	1.91
Westerly WPCP (Windsor)	P	24	7	-	24	1	-	24	3	1.13
Woodstock WPCP		24	0	-	24	1	28.0	23	7	1.19

P - Primary Plant
O of C - Out of Compliance

TABLE 18. LAKE ONTARIO/ST. LAWRENCE NON-COMPLIANCE AVERAGES FOR 1984 & 1985

PLANT		BOD_5			TSS			TP		
		# MO's DATA	# MO's O of C	AVERAGE FOR MO's O of C	# MO's DATA	# MO's O of C	AVERAGE FOR MO's O of C	# MO's DATA	# MO's O of C	AVERAGE FOR MO's O of C
Belleville WPCP		24	9	42.8	24	4	38.3	24	4	1.56
Brockville WPCP	P	24	1	-	24	0	-	24	9	1.26
Skyway WPCP (Burlington)		24	0	-	24	0	-	24	2	1.49
Bolton WPCP		17	0	-	17	0	-	17	1	1.04
Campbellford WPCP	X	23	0	-	24	0	-	24	4	1.24
Cobourg WPCP No.1	X	23	1	31.1	23	0	-	22	5	3.13
Cornwall WPCP	P	24	11	-	24	3	-	24	10	1.20
Dundas WPCP		24	0	-	24	1	30.0	24	7	1.19
Anger Ave. WPCP (Fort Erie)	P	22	4	-	22	11	-	22	4	1.18
Baker Rd. WPCP (Grimsby)		24	1	26.0	24	0	-	23	1	1.04
Acton WPCP + Lagoon (Halton Hills)		24	0	-	24	0	-	24	3	1.28
Georgetown WPCP (Halton Hills)		24	1	27.0	24	0	-	24	5	1.75
Woodward Ave. WPCP	X	24	7	35.3	24	6	34.5	24	17	1.49
Iroquois WPCP	P	9	8	-	9	9	-	8	6	2.59
Kingston WPCP	P	24	3	-	24	3	-	24	6	1.19
Kingston Twp. WPCP		18	2	28.5	18	2	28.0	18	2	1.18
Highland Creek WPCP (Metro Toronto)		24	11	36.1	24	6	31.7	24	2	1.10
Humber WPCP (Metro Toronto)		24	0	-	24	6	36.3	24	16	1.50
Main WPCP (Metro Toronto)		24	7	30.4	24	5	39.4	24	11	1.27
North Toronto WPCP (Metro Toronto)		24	1	26.0	24	0	-	24	5	1.13
Milton WPCP		22	0	-	22	0	-	20	0	-
Clarkson WPCP (Mississauga)		24	0	-	24	0	-	24	3	1.13
Lakeview WPCP (Mississauga)		24	0	-	24	3	27.0	24	2	1.17
Napanee WPCP		24	0	-	24	1	28.0	24	20	2.15
Port Darlington WPCP (Newcastle)		21	3	53.7	21	2	38.1	21	9	2.16
Stamford WPCP (Niagara Falls)	P	24	6	-	24	1	-	24	1	1.07
South East WPCP (Oakville)		23	0	-	23	0	-	23	7	1.25
South West WPCP (Oakville)		23	0	-	23	2	26.3	23	7	1.49
Orangeville WPCP		24	0	-	24	0	-	24	0	-
Harmony Creek WPCP No.1 (Oshawa)		18	1	60.0	18	2	41.4	24	7	1.45
Harmony Creek WPCP No.2 (Oshawa)		18	1	41.0	18	0	-	24	6	1.50
Peterborough WPCP		23	1	28.0	23	0	-	22	6	1.33
Duffin Creek WPCP (Pickering)		23	0	-	24	1	34.0	24	9	1.27
Picton WPCP		23	0	-	23	1	32.0	23	2	1.90
Port Colborne WPCP (Seaway)		24	1	33.7	24	3	33.5	24	13	1.57
Port Hope WPCP		23	0	-	23	0	-	23	0	-
Prescott-Edwardsburgh WPCP	P	24	4	-	24	3	-	24	1	1.20
Port Dalhousie WPCP (St. Catharines)		24	1	27.0	24	0	-	24	0	-
Port Weller WPCP (St. Catharines)		24	1	23.0	24	1	33.8	24	2	1.11
Trenton WPCP		24	0	-	24	1	26.0	24	1	1.20
Welland WPCP		24	1	25.5	24	0	-	24	2	1.10
Corbett Creek WPCP (Whitby)		22	3	66.7	24	3	35.7	24	3	1.21
Pringle Creek WPCP No.1 (Whitby)		24	5	62.4	24	4	36.8	24	5	1.51
Pringle Creek WPCP No.2 (Whitby)		24	5	70.0	24	6	31.8	23	9	1.36

P - Primary Plant

X - No Chemicals Used for P Removal

O of C - Out of Compliance

TABLE 19. UPPER GREAT LAKES NON-COMPLIANCE AVERAGES FOR 1984 & 1985

PLANT		BOD$_5$			TSS			TP		
		# MO's DATA	# MO's 0 of C	AVERAGE FOR MO's 0 of C	# MO's DATA	# MO's 0 of C	AVERAGE FOR MO's 0 of C	# MO's DATA	# MO's 0 of C	AVERAGE FOR MO's 0 of C
Barrie WPCP		24	0	-	24	1	33.0	23	4	1.28
Bradford WPCP		23	0	-	24	0	-	23	0	--
Collingwood WPCP		24	0	-	23	2	34.5	23	18	1.98
Esten Lake WPCP (Elliot Lake)		22	2	45.5	24	0	-	24	13	1.78
Goderich WPCP		24	0	-	24	0	-	24	11	1.32
Hanover WPCP		24	1	29.2	24	0	-	24	7	1.20
Huntsville WPCP		15	0	-	19	1	43.1	19	2	1.81
Midland WPCP		22	1	43.8	22	0	0	22	1	1.12
North Bay WPCP		24	5	30.1	24	14	34.9	24	22	1.67
Orillia WPCP		23	6	38.5	24	3	47.2	24	3	1.54
Owen Sound WPCP	P	24	3	-	24	0	-	24	5	1.07
Parry Sound WPCP		24	0	-	24	0	-	24	4	1.24
Port Elgin WPCP	X	24	1	75.0	24	0	-	24	22	1.87
Sault Ste. Marie WPCP	X P	24	0	-	24	0	-	24	24	4.42
Sturgeon Falls WPCP		24	0	-	24	0	-	22	0	-
Sudbury WPCP	X	24	1	26.9	24	0	-	24	24	1.97
Thunder Bay WPCP	P	24	1	-	24	6	-	24	14	1.40
Hamner, Val-Caron, Val-Therese WPCP (Valley East)		24	4	30.8	24	0	-	23	5	1.85
Mikkola WPCP (Walden)	X	24	0	-	24	2	26.9	24	24	2.50
Walkerton WPCP		24	5	28.5	24	0	-	24	9	1.19

P - Primary Plant

X - No Chemicals Used for P Removal

0 of C - Out of Compliance

<u>Note:</u> Wasaga Beach WPCP is an exfiltration plant.

TABLE 20. SUMMATION OF PLANT PHOSPHORUS REMOVAL STATUS FOR 1984
LAKE ERIE DRAINAGE BASIN

	PLANTS ACHIEVING TP < 0.5 mg/L	PLANTS ACHIEVING 0.5 < TP < 0.75 mg/L	PLANT ACHIEVING 0.75 < TP <1.0 mg/L	PLANTS ACHIEVING 1.0 < TP < 1.25 mg/L	PLANTS ACHIEVING TP > 1.25 mg/L	PLANTS NOT COMPLYING WITH ANNUAL AVERAGE	PLANTS COMPLYING WITH MONTHLY AVERAGE
	Tillsonburg WPCP	Brantford WPCP Preston WPCP (Cambridge) Dresden WPCP Fergus WPCP Ingersoll New WPCP Kitchener WPCP Leamington WPCP Belle River-Maidstone WPCP Paris WPCP Stratford WPCP Wallaceburg WPCP Westerly WPCP (Windsor)	Galt WPCP (Cambridge) Hespeler WPCP (Cambridge) Chatham WPCP Guelph WPCP Adelaide WPCP (London) Greenway WPCP (London) Oxford WPCP (London) Pottersburg WPCP (London) Vauxhall WPCP (London) Corunna P.V. Plant (Moore) Sarnia WPCP Simcoe WPCP Waterloo WPCP Woodstock WPCP	Dunnville WPCP St. Thomas WPCP Little R. WPCP (Windsor)	Amherstburg WPCP	Amherstburg WPCP Dunnville WPCP St. Thomas WPCP Little R. WPCP (Windsor)	Brantford WPCP Preston WPCP (Cambridge) Chatham WPCP Fergus WPCP Kitchener WPCP Pottersburg WPCP (London) Paris WPCP Sarnia WPCP Stratford WPCP Tillsonburg WPCP
Number Of Plants	1	12	14	3	1	4	10
Total Flow (10^3 m^3/day) (100%)	5.3 (0.7%)	284.6 (37.0%)	420.8 (54.6%)	54.8 (7.1%)	4.5 (0.6%)	59.2 (7.7%)	262.0 (34.0%)
Total P Loading (kg/day) (100%)	2.12 (0.3%)	196.31 (29.8%)	376.03 (57.1%)	65.44 (9.9%)	19.09 (2.9%)	84.55 (12.8%)	187.31 (28.4%)
Aggregate Average TP Concentration (mg/L)	0.40	0.69	0.90	1.19	4.20	1.43	0.71

TABLE 21. SUMMATION OF PLANT PHOSPHORUS REMOVAL STATUS FOR 1985
LAKE ERIE DRAINAGE BASIN

	PLANTS ACHIEVING TP < 0.5 mg/L	PLANTS ACHIEVING 0.5 < TP < 0.75 mg/L	PLANT ACHIEVING 0.75 < TP <1.0 mg/L	PLANTS ACHIEVING 1.0 < TP < 1.25 mg/L	PLANTS ACHIEVING TP > 1.25 mg/L	PLANTS NOT COMPLYING WITH ANNUAL AVERAGE	PLANTS COMPLYING WITH MONTHLY AVERAGE
	Dresden WPCP Stratford WPCP Wallaceburg WPCP	Dunnville WPCP Fergus WPCP Oxford WPCP (London) Pottersburg WPCP (London) Vauxhall WPCP (London) Paris WPCP Simcoe WPCP Waterloo WPCP	Brantford WPCP Galt WPCP (Cambridge) Preston WPCP (Cambridge) Guelph WPCP Ingersoll New WPCP Kitchener WPCP Leamington WPCP Adelaide WPCP (London) Greenway WPCP (London) Belle River-Maidstone WPCP Corunna P.V. Plant Sarnia WPCP Tillsonburg WPCP Little R. WPCP (Windsor) Westerly WPCP (Windsor)	Chatham WPCP St. Thomas WPCP Woodstock WPCP	Amherstburg WPCP Hespeler WPCP (Cambridge)	Amherstburg WPCP Chatham WPCP Hespeler WPCP (Cambridge) St. Thomas WPCP Woodstock WPCP	Galt WPCP (Cambridge) Dresden WPCP Dunnville WPCP Fergus WPCP Kitchener WPCP Adelaide WPCP (London) Oxford WPCP (London) Simcoe WPCP Stratford WPCP
Number Of Plants	3	8	15	3	2	5	9
Total Flow (10^3 m^3/day) (100%)	36.2 (4.3%)	108.3 (12.9%)	610.3 (72.9%)	72.6 (8.7%)	10.1 (1.2%)	82.6 (9.9%)	164.9 (19.7%)
Total P Loading (kg/day) (100%)	10.38 (1.5%)	74.02 (11.0%)	493.10 (73.0%)	76.32 (11.3%)	21.99 (3.3%)	97.93 (14.5%)	111.97 (16.6%)
Aggregate Average TP Concentration (mg/L)	0.29	0.68	0.81	1.05	2.19	1.19	0.68

TABLE 22. SUMMATION OF PLANT PHOSPHORUS REMOVAL STATUS FOR 1984
LAKE ONTARIO/ST. LAWRENCE DRAINAGE BASIN

	PLANTS ACHIEVING TP < 0.5 mg/L	PLANT ACHIEVING 0.5 < TP < 0.75 mg/L	PLANT ACHIEVING 0.75 < TP <1.0 mg/L	PLANTS ACHIEVING 1.0 < TP < 1.25 mg/L	PLANTS ACHIEVING TP > 1.25 mg/L	PLANTS NOT COMPLYING WITH ANNUAL AVERAGE	PLANTS COMPLYING WITH MONTHLY AVERAGE
	Milton WPCP Orangeville WPCP Welland WPCP	Skyway WPCP (Burlington) Bolton WPCP(Caledon) Campbellford WPCP Cobourg WPCP No. 1 Baker Rd. WPCP (Grimsby) Acton WPCP & Lag. (Halton Hills) Stamford WPCP (Niagara Falls) Picton WPCP Port Hope WPCP Port Dalhousie WPCP (St. Catharines) Port Weller WPCP (St. Catharines) Trenton WPCP	Cornwall WPCP Dundas WPCP Anger Ave. WPCP(Fort Erie) Kingston WPCP Kingston TWP. WPCP Highland Cr. WPCP (Metro Toronto) Main WPCP (Metro Toronto) North Toronto WPCP (Metro Toronto) Clarkson WPCP(Mississauga) Lakeview WPCP(Mississauga) South East WPCP (Oakville) South West WPCP (Oakville) Peterborough WPCP York-Durham WPCP (Pickering) Prescott-Edwardsburgh WPCP Corbett Cr. WPCP (Whitby) Pringle Cr. WPCP No. 1 (Whitby)	Belleville WPCP Brockville WPCP Georgetown WPCP (Halton Hills) Harmony Cr. 1 & 2 (Oshawa) Seaway WPCP (Port Colborne) Pringle Cr. WPCP No.2 (Whitby)	Woodward Ave. WPCP (Hamilton) Iroquois WPCP Humber WPCP (Metro Toronto) Napanee WPCP Port Darlington WPCP (Newcastle)	Belleville WPCP Brockville WPCP Georgetown WPCP (Halton Hills) Harmony Cr. 1 & 2 WPCP (Oshawa) Seaway WPCP (Port Colborne) Pringle Cr. WPCP No. 2 (Whitby) Woodward Ave. WPCP (Hamilton) Iroquois WPCP Humber WPCP (Metro Toronto) Napanee WPCP Port Darlington WPCP (Newcastle)	Bolton WPCP(Caledon) Milton WPCP Orangeville WPCP Port Hope WPCP Port Dalhousie WPCP (St. Catharines) Port Weller WPCP (St. Catharines) Welland WPCP
Number of Plants	3	12	17	7	5	12	7
Total Flow (10^3 m^3/day) (100%)	51.1 (1.9%)	272.4 (10.2%)	1525.5 (57.1%)	143.8 (5.4%)	678.7 (25.4%)	822.5 (30.8%)	131.3 (4.9%)
Total P Loading (kg/day) (100%)	18.40 (0.7%)	174.78 (6.5%)	1415.2 (52.6%)	150.29 (5.6%)	929.91 (34.6%)	1080.11 (40.2%)	63.06 (2.3%)
Aggregate Average TP Concentration (mg/L)	0.36	0.64	0.93	1.05	1.37	1.31	0.48

TABLE 23. SUMMATION OF PLANT PHOSPHORUS REMOVAL STATUS FOR 1985
LAKE ONTARIO/ST. LAWRENCE DRAINAGE BASIN

	PLANTS ACHIEVING TP < 0.5 mg/L	PLANTS ACHIEVING 0.5 < TP < 0.75 mg/L	PLANT ACHIEVING 0.75 < TP <1.0 mg/L	PLANTS ACHIEVING 1.0 < TP < 1.25 mg/L	PLANTS ACHIEVING TP > 1.25 mg/L	PLANTS NOT COMPLYING WITH ANNUAL AVERAGE	PLANTS COMPLYING WITH MONTHLY AVERAGE
	Belleville WPCP Bolton WPCP(Caledon) Georgetown WPCP (Halton Hills) Milton WPCP Stamford WPCP (Niagara Falls) Orangeville WPCP Port Dalhousie WPCP (St. Catharines)	Skyway WPCP (Burlington) Anger Ave. WPCP (Fort Erie) Baker Rd. WPCP (Grimsby) Acton WPCP(Halton Hills) Lakeview WPCP (Mississauga) Harmony Cr. No. 1 WPCP (Oshawa) Harmony Cr. No. 2 WPCP (Oshawa) Picton WPCP Port Hope WPCP Prescott-Edwardsburgh WPCP Trenton WPCP Corbett Cr. WPCP(Whitby) Pringle Cr. WPCP No. 1 (Whitby)	Brockville WPCP Campbellford WPCP Cornwall WPCP Dundas WPCP Kingston WPCP Kingston TWP WPCP Highland Cr. WPCP (Metro Toronto) North Toronto WPCP Clarkson WPCP (Mississauga) Port Darlington WPCP (Newcastle) South East WPCP (Oakville) South West WPCP (Oakville) Peterborough WPCP Port Weller WPCP (St. Catharines) Pringle Cr. WPCP No.2 (Whitby) Welland WPCP	Humber WPCP (Metro Toronto) Main WPCP (Metro Toronto) York Durham WPCP (Pickering) Seaway WPCP (Port Colborne)	Cobourg WPCP No. 1 Woodward Ave. WPCP (Hamilton) Iroquois WPCP Napanee WPCP	Cobourg WPCP No. 1 Woodward Ave. WPCP (Hamilton) Humber WPCP (Metro Toronto) Main WPCP (Metro Toronto) Napanee WPCP York Durham WPCP (Pickering) Seaway WPCP (Port Colborne) Iroquois WPCP	Belleville WPCP Georgetown WPCP (Halton Hills) Harmony Cr. No.2 WPCP (Oshawa) Baker Rd. WPCP (Grimsby) Kingston Twp. WPCP Highland Cr. (Metro Toronto) Milton WPCP Lakeview WPCP (Mississauga) Stamford WPCP (Niagara Falls) Orangeville WPCP Port Hope WPCP Prescott-Edwardsburg WPCP Port Dalhousie WPCP (St. Catharines) Trenton WPCP Corbett Cr. WPCP(Whitby)
Number of Plants	7	13	16	4	4	8	15
Total Flow (10^3 m^3/day) (100%)	174.4 (6.2%)	429.8 (15.4%)	641.3 (22.9%)	1225.1 (43.8%)	328.3 (11.7%)	1553.4 (55.6%)	660.2 (23.6%)
Total P Loading (kg/day) (100%)	74.78 (2.8%)	281.72 (10.6%)	532.89 (20.1%)	1326.11 (50.0%)	435.19 (16.4%)	1761.30 (66.4%)	411.42 (15.5%)
Aggregate Average TP Concentration (mg/L)	0.43	0.66	0.83	1.08	1.33	1.13	0.62

TABLE 24. SUMMATION OF PLANT PHOSPHORUS REMOVAL STATUS FOR 1984
LAKE HURON DRAINAGE BASIN

	PLANTS ACHIEVING TP < 0.5 mg/L	PLANT ACHIEVING 0.5 < TP < 0.75 mg/L	PLANT ACHIEVING 0.75 < TP <1.0 mg/L	PLANTS ACHIEVING 1.0 < TP < 1.25 mg/L	PLANTS ACHIEVING TP > 1.25 mg/L	PLANTS NOT COMPLYING WITH ANNUAL AVERAGE	PLANTS COMPLYING WITH MONTHLY AVERAGE
	Huntsville WPCP Orillia WPCP Sturgeon Falls WPCP	Midland WPCP	Barrie WPCP Bradford WPCP Hanover WPCP Owen Sound WPCP Parry Sound WPCP Walkerton WPCP	Goderich WPCP Hamner, Val-Caron, Val-Therese WPCP (Valley East)	Collingwood WPCP Esten Lake WPCP (Elliot Lake) North Bay WPCP Port Elgin WPCP Sault Ste. Marie WPCP Sudbury WPCP Thunder Bay WPCP* Mikkola WPCP (Walden)	Collingwood WPCP Eastern L. WPCP (Elliott Lake) Goderich WPCP North Bay WPCP Port Elgin WPCP Sault Ste. Marie WPCP Sudbury WPCP Thunder Bay WPCP* Hamner, Val-Caron, Val-Therese WPCP (Valley East) Mikkola WPCP (Walden)	Bradford WPCP Huntsville WPCP Orillia WPCP Sturgeon Falls WPCP
Number of Plants	3	1	6	2	7	9	4
Total Flow (10^3 m^3/day) (100%)	29.8 (10.6%)	9.3 (3.3%)	61.5 (21.9%)	14.7 (5.2%)	166.1 (59.0%)	180.8 (64.2%)	33.1 (11.8%)
Total P Loading (kg/day) (100%)	11.20 (2.2%)	5.17 (1.0%)	55.81 (11.2%)	16.38 (3.3%)	411.31 (82.3%)	427.69 (85.6%)	13.80 (2.8%)
Aggregate Average TP Concentration (mg/L)	0.38	0.56	0.91	1.11	2.48	2.37	0.42

* Thunder Bay WPCP is not included in Basin Summary Statistics at bottom since it discharges into Lake Superior Drainage Basin.

TABLE 25. SUMMATION OF PLANT PHOSPHORUS REMOVAL STATUS FOR 1985
LAKE HURON DRAINAGE BASIN

	PLANTS ACHIEVING TP < 0.5 mg/L	PLANT ACHIEVING 0.5 < TP < 0.75 mg/L	PLANT ACHIEVING 0.75 < TP <1.0 mg/L	PLANTS ACHIEVING 1.0 < TP < 1.25 mg/L	PLANTS ACHIEVING TP > 1.25 mg/L	PLANTS NOT COMPLYING WITH ANNUAL AVERAGE	PLANTS COMPLYING WITH MONTHLY AVERAGE
	Bradford WPCP Sturgeon Falls WPCP	Barrie WPCP Midland WPCP Parry Sound WPCP Hamner Etc. WPCP (Valley East) Orillia WPCP	Goderich WPCP Hanover WPCP Huntsville WPCP Owen Sound WPCP Walkerton WPCP	Esten L. WPCP (Elliot Lake) Thunder Bay WPCP*	Collingwood WPCP North Bay WPCP Port Elgin WPCP Sault Ste. Marie WPCP Sudbury WPCP Mikkola WPCP (Walden)	Collingwood WPCP Esten L. WPCP (Elliott Lake) North Bay WPCP Port Elgin WPCP Sault Ste. Marie WPCP Sudbury WPCP Mikkola WPCP (Walden) Thunder Bay WPCP*	Barrie WPCP Bradford WPCP Midland WPCP Parry Sound WPCP Sturgeon Falls WPCP Hamner Etc. (Valley East)
Number of Plants	2	5	5	1	6	7	6
Total Flow (10^3 m^3/day) (100%)	8.7 (2.9%)	65.7 (21.8%)	48.7 (16.1%)	12.5 (4.1%)	166.2 (55.1%)	178.5 (59.2%)	55.2 (18.3%)
Total P Loading (kg/day) (100%)	3.88 (0.7%)	36.45 (6.9%)	41.57 (7.8%)	13.75 (2.6%)	434.45 (82.0%)	448.33 (84.6%)	29.2 (5.5%)
Aggregate Average TP Concentration (mg/L)	0.45	0.54	0.85	1.10	2.61	2.51	0.53

* Thunder Bay WPCP is not included in Basin Summary Statistics at bottom since it discharges into Lake Superior Drainage Basin.

size of out-of-compliance plants and the effluent concentration at these plants than by the number of plants out-of-compliance.

From the information in Tables 20 to 25, the ranges of annual average concentrations found for all plants that complied on a monthly average basis were calculated. For both 1984 and 1985, about 30 percent of all plants that complied on a monthly basis had annual average concentrations less than 0.5 mg/L, 50 percent had concentrations between 0.5 and 0.75 mg/L and 20 percent had concentrations greater than 0.75 mg/L. It appears that, in order to achieve monthly compliance, the majority of plants had to maintain annual average concentrations less than 0.75 mg/L; however, some plants did achieve monthly compliance with higher annual averages. This suggests that with good plant operation and monitoring, and low influent phosphorus and flow variability, higher annual average concentrations can be maintained, while still complying on a monthly basis. These observations cannot be validated with performance data from 1984 and 1985 because in these years plants were not attempting to achieve monthly compliance with the effluent phosphorus requirement.

2.5 Phosphorus Loadings to the Great Lakes Basin

Total flows from municipal treatment facilities larger than 4546 m^3/d, total phosphorus loadings and aggregate average phosphorus concentrations were calculated for 1981 to 1985 for each drainage basin (Lake Erie, Lake Ontario, Lake Huron and Lake Superior). The results of this analysis are presented in Table 26.

2.5.1 Lake Erie Basin

The total phosphorus loading to the Lake Erie Basin from WPCPs larger than 4546 m^3/d averaged 243 tonnes per year with no apparent trend over the time period for 1981 to 1985.

The aggregate average TP concentration in effluents from these WPCPs discharging to the Lake Erie Basin has shown a generally decreasing trend over the period from 1981 to 1985. The aggregate average concentration in 1984 and 1985 was approximately 0.8 mg/L, twenty percent lower than the IJC objective of 1.0 mg/L. The aggregate average concentration for the five year period has never exceeded 0.93 mg/L.

TABLE 26. SUMMARY OF BASIN FLOWS, PHOSPHORUS LOADINGS, AND AGGREGATE AVERAGE PHOSPHORUS CONCENTRATIONS

BASIN	PARAMETER	YEAR 1981	1982	1983	1984	1985
LAKE ERIE	Flow (1000 m^3/d)	701.7	742.0	762.0	770.0	837.5
	Loading (tonnes/yr)	229.4	250.7	246.9	240.5	246.7
	Agg. Avg. TP (mg/L)	0.90	0.93	0.89	0.86	0.81
LAKE ONTARIO/ ST. LAWRENCE	Flow (1000 m^3/d)	2584.1	2654.0	2702.7	2671.5	2798.9
	TP Loading (tonnes/yr)	1071.7	1026.6	949.5	981.3	967.5
	Agg. Avg. TP (mg/L)	1.14	1.06	0.96	1.01	0.95
LAKE HURON	Flow (1000 m^3/d)	260.8	272.5	272.5	281.4	301.8
	TP Loading (tonnes/yr)	211.1	152.0	163.1	182.5	193.5
	Agg. Avg. TP (mg/L)	2.22	1.53	1.64	1.78	1.76
LAKE SUPERIOR	Flow (1000 m^3/d)	81.7	96.8	100.6	104.2	113.8
	TP Loading (tonnes/yr)	93.7	109.6	55.2	48.3	42.0
	Agg. Avg. TP (mg/L)	3.14	3.10	1.50	1.27	1.01

2.5.2 Lake Ontario/St. Lawrence River Basin

Unlike the situation in the Lake Erie Basin, there has been a declining trend in the total phosphorus loading to the Lake Ontario/St. Lawrence River Basin, from a total loading in excess of 1000 tonnes/year to approximately 970 tonnes/year over the five-year period. Municipal treatment plants in the Lake Ontario/St. Lawrence River basin have shown the same trend toward better phosphorus removal performance over the time period from 1981 to 1985 as plants in the Lake Erie basin. The aggregate average TP concentration has declined from 1.14 mg/L in 1981 to 0.95 mg/L in 1985.

2.5.3 Lake Huron Basin

There was a major decrease in the TP loading to the Lake Huron Basin between 1981 and 1982. Since that time, the basin TP loading has progressively increased. This increase is related to the increased flow from plants discharging to the Lake Huron Basin and to an increase in the aggregate average TP concentration from 1982 to 1985. There was a significant reduction in the aggregate average TP concentration in 1982 compared to 1981. There were four plants (Port Elgin WPCP, Sault Ste. Marie WPCP, Sudbury WPCP and Walden WPCP) that had not implemented phosphorus removal by the end of 1985. As a result, the aggregate average TP concentration in the effluents from plants in the Lake Huron Basin has consistently exceeded 1 mg/L. It should be noted that Wasaga Beach WPCP, which is classified as an exfiltration plant, has not been included in the analysis of Lake Huron Basin loadings.

2.5.4 Lake Superior Basin

The Thunder Bay WPCP is the only plant greater than 4546 m^3/day (1 MGD) discharging into the Lake Superior drainage basin. A definite decrease in basin TP loading was observed in 1983 due to implementation of phosphorus removal processes at the Thunder Bay WPCP. Performance of the phosphorus removal system at Thunder Bay has progressively improved since implementation. In 1985, effluent quality was near 1 mg/L.

2.5.5 Total Basin Loadings

There has been a general trend toward improved phosphorus removal process performance in all Great Lakes basins over the time period from 1981 to 1985, with the exception of the Lake Huron Basin. In 1985, the aggregate average phosphorus concentration from plants larger than 4546 m^3/d discharging to the Lake Erie and Lake Ontario/St. Lawrence River was less than 1 mg/L. Discharges to the Lake Superior basin from the Thunder Bay WPCP were near 1 mg/L, averaging 1.01 mg/L. The aggregate average concentration in the Lake Huron Basin exceeded 1 mg/L because four plants had not, by the end of 1985, implemented phosphorus removal.

Despite a linear increase in flow in all receiving basins over the time period from 1981 to 1985, the total phosphorus loadings to the Great Lakes decreased from 1606 tonnes/yr to 1450 tonnes/yr, a decline of approximately 10 percent. Plants in the Lake Ontario/St. Lawrence River Basin accomplished the largest reduction over this time period (104 tonnes/year).

3.0 FIELD INVESTIGATIONS

3.1 Objectives and Approach

The goals of the field studies were to define critical factors influencing phosphorus removal at the facilities under investigation and to demonstrate at selected facilities that phosphorus removal efficiency could be cost-effectively improved at low capital cost through improved plant operation.

Each of the 96 facilities in the Great Lakes Basin were contacted to establish current phosphorus removal practices. As a result of these discussions and the historical data review, the summary data presented in Tables 27 to 29 were developed. Included in these summary tables are the 1984 and 1985 annual average effluent phosphorus concentrations, the number of months of TP compliance in these years, the chemical and dosage used for phosphorus removal and the reasons that were suggested for phosphorus removal performance. The most commonly suggested reasons for superior phosphorus removal performance were low clarifier surface loading, effluent polishing, polymer addition, and low influent P concentration. Reasons suggested most often for poor phosphorus removal performance included high clarifier surface loading, poor (or no) dosage control, inadequate chemical dosage, and sludge management problems and/or sludge settleability problems.

From these data, twelve WPCPs were selected for field evaluation in Phase 2 of the program to confirm the Phase 1 findings. In the subsequent Phase 3 investigations, four of the twelve Phase 2 plants were selected for further evaluation.

3.2 Phase 2 Program Results

3.2.1 Plant Selection

A total of twelve plants were to be selected, five of which had historically demonstrated excellent phosphorus removal performance and seven of which had consistently not complied with MOE phosphorus requirements. If the critical factors were obvious, and no additional information was necessary, then the plant was not considered to be a candidate. Tables 30 and 31

TABLE 27. SUMMARY OF PLANT PHOSPHORUS REMOVAL PERFORMANCE AND METHODS FOR LAKE ERIE DRAINAGE BASIN

PLANT	AVERAGE EFFLUENT TP (mg/L)		NUMBER OF MONTHS TP > 1 mg/L		CHEMICAL USED FOR P-REMOVAL	DOSAGE mg Metal/L		METAL:TP MOLAR RATIO		FACTORS INFLUENCING TP REMOVAL		
										RANK - MOST IMPORTANT		
	1984	1985	1984	1985		1984	1985	1984	1985	1.	2.	3.
Amherstburg WPCP	4.2	3.25	10/10	10	$FeCl_3$	8.1	15.0	0.95:1	1.6:1	Inadequate plant capacity	Operator problems	Higher than avg. chemical required
Brantford WPCP	0.74	0.75	0	1	$FeCl_2$	9.4	8.6	1.0:1	0.9:1	Adequate chemical dosage		
Galt WPCP (Cambridge)	0.89	0.80	2	0	$FeCl_3$	4.9	6.3	0.5:1	0.5:1	Good sludge settleability		
Hespeler WPCP (Cambridge)	0.92	1.27	4	7	$FeCl_3$/$FeCl_3$ 50/50	7.7	7.7	1.2:1	0.7:1	High clarifier surface loading	Poor dosage control	Poor sludge settleability
Preston WPCP (Cambridge)	0.57	0.77	0	2/11	$FeCl_3$	4.9	5.4	0.4:1	0.46:1	Low clarifier surface loading	Good sludge settleability	Good dosage control
Chatham WPCP	0.78	1.02	0	5	$FeCl_2$	10.8	9.3	0.42:1	0.28:1	Effluent polishing ponds	Low clarifier surface loading	Superior plant operation
Dresden WPCP	0.55	0.33	3	0	Alum (-'85) Poly Alum Chloride ('86)	3.9	5.0	1.0:1	1.23:1	Low clarifier surface loading	High chemical dosage	Separate sewers
Dunnville WPCP	1.02	0.62	3	0	$FeCl_2$	2.6	2.5	0.39:1	0.36:1	Low clarifier surface loading	Good sludge settleability	Bypassing during peak infiltration
Fergus WPCP	0.64	0.55	0	0								
Guelph WPCP	0.96	0.83	6	2	Alum	6.5	6.5	1.14:1	1.16:1	Effluent filtration	High chemical dosage	Superior plant operation
Ingersoll New WPCP	0.52	0.87	2	3	$FeCl_3$	6.0	7.3	0.44:1	0.59:1	Poor dosage control	Infiltration/inflow	
Kitchener WPCP	0.69	0.76	0	0	$FeSO_4$	7.7	9.3	0.6:1	0.75:1	Good dosage control	Low clarifier surface loading	Superior plant operation
Leamington WPCP	0.58	0.99	2/10	4	$FeCl_3$	4.4	1.6	1.34:1	0.53:1			
Adelaide WPCP (London)	0.93	0.87	2	0	$FeCl_2$	--	9.0	--	0.63:1			
Greenway WPCP (London)	0.93	0.77	4	2	$FeCl_2$	--	3.24	--	0.3:1			
Oxford WPCP (London)	0.88	0.74	3	0	$FeCl_2$	--	17.7	--	1.3:1	High chemical dosage	Low clarifier surface loading	
Pottersburg WPCP (London)	0.85	0.63	0	1	$FeCl_2$	--	6.1	--	0.65:1	Industrial waste factors	Low clarifier surface loading	High chemical dosage
Vauxhall WPCP (London)	0.79	0.63	1	1	Lime	--	42.0	--	--	Industrial waste factors	Low clarifier surface loading	
Belle River-Maidstone WPCP	0.62	0.85	2	3	Alum	3.02	2.26	1.27:1	0.82:1	Low clarifier surface loading	Low influent P concentration	
Corunna P.V. Plant (Moore)	0.87	0.85	7	5	Alum	7.32	7.79	1.32:1	1.14:1	Low clarifier surface loading	No industrial waste factors	
Paris WPCP	0.58	0.55	0	1	$FeCl_3$	27.0	24.0	2.1:1	1.4:1	Only 35% design capacity	High chemical dosage	
Sarnia WPCP	0.78	0.82	0	1	$FeCl_3$/Polymer in summer	7.2	7.2	0.74:1	0.75:1	Low clarifier surface loading	Polymer addition	
Simcoe WPCP	0.79	0.71	1	0	$FeCl_3$	10.0	8.3	0.8:1	0.68:1	Effluent polishing/filtration	Low clarifier surface loading	Low peak flow/variable pump speeds
St. Thomas WPCP	1.20	1.14	6/11	5	Alum	4.3	4.3	1.12:1	0.94:1	Point of chemical addition	Complex plant operation	Low P removal chemical dosage
Stratford WPCP	0.56	0.23	0	0	Alum/$FeCl_2$	(Al)	4(Fe)	--	0.53:1	Effluent filtration	High chemical dosage	
Tillsonburg WPCP	0.40	0.80	0	1	Alum	4.0	3.3	0.85:1	0.63:1	Low clarifier surface loading	Industrial waste factors	Good sludge settleability
Wallaceburg WPCP	0.67	0.42	2	1/9	$FeCl_3$	9.5	5.9	1.24:1	0.74:1	High chemical dosage	Good plant operation	
Waterloo WPCP	0.98	0.75	4	1	$FeCl_2$	5.3	6.2	0.44:1	0.53:1	Low clarifier surface loading	Good dosage control	Good sludge settleability
Little R. WPCP (Windsor)	1.22	0.83	5	3	$AlCl_3$	7.8	6.6	1.6:1	1.6:1	Adequate chemical dosage	Satisfactory plant performance	
Westerly WPCP (Windsor)	0.73	0.86	1	2	$FeCl_3$ ('84) Alum ('85)	1.57	3.3	1.7:1	0.85:1	Presently using $AlCl_3$ (1986)	Adequate chemical dosage	Good plant operation
Woodstock WPCP	0.95	1.02	2	5/11	$FeCl_3$	6.06	5.4	0.79:1	0.83:1	Poor dosage control		

TABLE 28. SUMMARY OF PLANT PHOSPHORUS REMOVAL PERFORMANCE AND METHODS FOR LAKE ONTARIO DRAINAGE BASIN

PLANT	AVERAGE EFFLUENT TP (mg/L)		NUMBER OF MONTHS TP > 1 mg/L		CHEMICAL USED FOR P-REMOVAL	DOSAGE mg Metal/L		METAL:TP MOLAR RATIO		FACTORS INFLUENCING TP REMOVAL RANK - MOST IMPORTANT		
	1984	1985	1984	1985		1984	1985	1984	1985	1.	2.	3.
Belleville WPCP	1.02	0.48	4	0	$FeCl_3/FeCl_2$	9.1	9.1	1.1:1	1.4:1	Present dosage 15 mg/L Fe^{3+}	Under construction until 1985	
Brockville WPCP	1.01	0.87	6	3	$FeCl_3$	9.1	10.2	1.13:1	1.4:1	High chemical dosage	Low influent P concentration	Good dosage control
Skyway WPCP (Burlington)	0.72	0.74	1	1	$FeCl_3$	3.7	3.8	0.26:1	0.31:1	Good sludge settleability	Low clarifier surface loading	Superior Plant operation
Bolton WPCP*	0.55	0.47	0	1/10	NA	--	--	--	--	NA		
Campbellford WPCP	0.69	0.86	1/11	3/11	No chemicals used.	--	--	--	--	Low influent P concentration		
Cobourg WPCP No. 1	0.66	1.54	2	3/10	No chemicals used.	--	--	--	--	No chemicals added		
Cornwall WPCP	0.98	0.99	4	6	Alum/polymer	4.7	4.8	2:17	2:1:1	Polymer addition	Low influent P concentration	High chemical dosage
Dundas WPCP	0.78	0.77	4	3	Alum	3.2	3.7	0.64:1	0.72:1	Low clarifier surface loading	Good sludge settleability	High chemical dosage
Anger Ave. WPCP (Fort Erie)	0.77	0.75	2/10	2	$FeCl_3$	10	11	1.9:1	1.7:1	High chemical dosage	Industrial waste factors	Low clarifier surface loading
Baker Rd. WPCP (Grimsby)	0.72	0.60	1/11	0	$FeSO_4$	5.7	9.8	--	1.0:1	Low clarifier surface loading	High chemical dosage	Good sludge settleability
Acton WPCP + Lagoon (Halton Hills)	0.55	0.57	2	1	$FeCl_3$	12.9	12.7	1.0:1	1.3:1	Effluent filtration	Tertiary ponds	High chemical dosage
Georgetown WPCP (Halton Hills)	1.16	0.49	5	0	$FeCl_3$	12.4	13.7	0.54:1	0.74:1	Effluent filtration	High chemical dosage	Low clarifier surface loading
Woodward Ave. WPCP (Hamilton)	1.27	1.31	8	9	No chemicals used.	--	--	--	--	No chemicals added		
Iroquois WPCP	2.15	1.90	6/8	-	$FeCl_3$	21.4	17.5	0.4:1	--	SS carry-over	Low chemical dosage	
Kingston WPCP	0.96	0.78	4	2	$FeCl_3$	8.1	7.1	1.3:1	0.9:1	High chemical dosage	Low influent P concentration	
Kingston TWP WPCP	0.91	0.89	2	0	Alum	--	5.1	--	0.93:1	Superior plant operation	Good dosage control	Low clarifier surface loading
Highland Creek WPCP (Metro Toronto)	0.91	0.77	2	0	$FeCl_2$	6.1	7.5	0.60:1	0.75:1	Adequate chemical dosage		
Humber WPCP (Metro Toronto)	1.43	1.08	10	6	$FeCl_2$	6.3	7.2	0.35:1	0.45:1	Sludge management problems	Low chemical dosage	
Main WPCP (Metro Toronto)	0.97	1.09	4	7	$FeCl_2$	7.5	8.5	0.71:1	0.81:1	Adequate chemical dosage		
North Toronto WPCP (Metro Toronto)	0.85	0.85	3	2	$FeCl_2$	9.1	7.8	0.95:1	0.85:1	Adequate chemical dosage		
Milton WPCP	0.36	0.29	0/10	0/10	Alum	9.0	9.6	1.62:1	1.17:1	Effluent filtration	High chemical dosage	
Clarkson WPCP (Mississauga)	0.89	0.90	1	2	$FeCl_2$	11.6	12.6	0.8:1	0.87:1	Good dosage control	Low clarifier surface loading	Good sludge settleability
Lakeview WPCP (Mississauga)	0.85	0.65	2	0	$FeCl_2$	9.26	11.7	0.25:1	0.75:1	Good dosage control		
Napanee WPCP	2.46	1.41	11	9	$FeCl_2$	19.4	24.5	0.85:1	1.02:1	Industrial waste factors	Poor sludge settleability	High influent P concentration
Port Darlington WPCP (Newcastle)	1.83	0.93	6/10	3/11	Alum	1.91	1.85	0.4:1	0.32:1	Low chemical dosage		
Stamford WPCP (Niagara Falls)	0.63	0.46	1	0	$FeCl_3$	18.8	18.5	2:4:1	3:1:1	High chemical dosage	Low clarifier surface loading	Good dosage control
South East WPCP (Oakville)	0.87	0.86	4	3/11	Alum	4.8	8.1	0.7:1	0.98:1	Low clarifier surface loading	Good sludge settleability	Good dosage control
South West WPCP (Oakville)	0.93	0.91	4	3/11	$FeCl_3$	14.9	8.9	0.96:1	0.6:1	Poor sludge settleability	Industrial waste factors	Infiltration/combined flow
Orangeville WPCP	0.36	0.26	0	0	Alum	6.7	6.3	1.5:1	1.14:1	Effluent polishing	Good sludge settleability	Low clarifier surface loading
Harmony Cr. 1 WPCP (Oshawa)	1.02	0.61	6	1/6	Alum	--	22.9	--	4.2:1	High chemical dosage	Low clarifier surface loading	Industrial waste factors
Harmony Cr. 2 WPCP (Oshawa)	1.02	0.61	3	0/4	Alum	--	14.5	--	2.6:1	High chemical dosage	Low clarifier surface loading	
Peterborough WPCP	0.81	0.80	3/11	3/11	$FeSO_4$	3.3	3.1	0.6:1	0.53:1			
Duffin Creek WPCP (Pickering)	0.98	1.05	4	5	Alum	4.4	5.0	0.7:1	0.95:1	Low chemical dosage		
Picton WPCP	0.68	0.50	1	1/11	Alum	3.4	4.0	--	1.8:1	High chemical dosage	Good dosage control	
Seaway WPCP (Port Colborne)	1.15	1.13	7	6	$FeCl_3$	8.0	10.3	0.63:1	0.48:1	High influent P concentration	Industrial waste factors	Sludge management problems
Port Hope WPCP	0.53	0.56	1	0/11	Alum	2.8	2.8	1.0:1	1.7:1	Low influent P concentration	Superior plant operation	Good dosage control
Prescott-Edwardsburgh WPCP	0.88	0.61	1	0	$FeCl_3$/Polymer	8.3	7.0	0.9:1	0.9:1	Polymer addition	High chemical dosage	Good dosage control
Port Dalhousie WPCP (St. Catharines)	0.55	0.39	0	0	$FeCl_3$	13.3	11.2	1.15:1	0.9:1	Low clarifier surface loading	High chemical dosage	Low influent P concentration
Port Weller WPCP (St. Catharines)	0.57	0.78	0	2	Alum	5.0	4.0	1.1:1	0.82:1	Good sludge settleability	Low clarifier surface loading	High chemical dosage
Trenton WPCP	0.58	0.67	1	0	$FeCl_2$	15.0	10.4	1.4:1	0.9:1	High chemical dosage	Low clarifier surface loading	
Welland WPCP	0.36	0.76	0	2	$FeCl_2$	2.7	3.7	0.22:1	0.58:1	Low clarifier surface loading	Good sludge settleability	
Corbett Cr. WPCP (Whitby)	0.85	0.59	3	0	Alum	7.1	6.05	1.7:1	1.4:1	Low clarifier surface loading	High chemical dosage	
Pringle Cr. WPCP No. 1 (Whitby)	0.90	0.70	3	2	Alum	4.0	4.2	1.2:1	1.8:1	Low influent P concentration	High chemical dosage	
Pringle Cr. WPCP No. 2 (Whitby)	1.09	0.94	4/11	5	Alum	4.37	3.05	1.33:1	1.28:1	Low influent P	Low clarifier surface loading	

* Plant not opertional after 1985.

Note: Newmarket WPCP was not operational in 1984 or 1985.

TABLE 29. SUMMARY OF PLANT PHOSPHORUS REMOVAL PERFORMANCE AND METHODS FOR UPPER GREAT LAKES DRAINAGE BASIN

PLANT	AVERAGE EFFLUENT TP (mg/L)		NUMBER OF MONTHS TP > 1 mg/L		CHEMICAL USED FOR P-REMOVAL	DOSAGE mg Metal/L		METAL:TP RATIO		FACTORS INFLUENCING TP REMOVAL		
										RANK - MOST IMPORTANT		
	1984	1985	1984	1985		1984	1985	1984	1985	1.	2.	3.
Barrie WPCP	0.97	0.50	4	0	Alum	5.0	5.0	0.68:1	0.58:1	Superior plant operation	Low clarifier surface loading	
Bradford WPCP	0.77	0.42	0	0	Alum	6.3	6.7	0.83:1	1.1:1	Effluent filtration	Polymer addition	Low clarifier surface loading
Collingwood WPCP	1.49	1.92	8/11	10	Alum	2.9	3.8	0.38:1	0.39:1	High clarifier surface loading	High influent P concentration	Sludge management problems
Esten Lake WPCP (Elliot Lake)	1.33	1.10	6	7	Alum							
Goderich WPCP	1.10	0.87	8	3	Alum	--	1.89	--	0.5:1	High clarifier surface loading	Infiltration/inflow	
Hanover WPCP	0.86	0.87	4	3	Alum	4.6	4.2	0.82:1	0.60:1	Low clarifier surface loading	Good dosage control	Superior plant operation
Huntsville WPCP	0.31	0.76	0	2/7	Alum							
Midland WPCP	0.56	0.57	1/11	0	$FeCl_3$	7.3	5.1	0.82:1	0.64:1	Low influent P concentration	High chemical dosage	Low clarifier surface loading
North Bay WPCP	1.50	1.68	10	12	$FeCl_3/FeCl_2$ 50/50	20	20	0.76:1	1.2:1	Infiltration/inflow	Poor dosage control	Construction
Orillia WPCP	0.41	0 58	0	3	Alum	3.9	3.1	2.1:1	1.13:1	Low influent P concentration	High chemical dosage	Industrial waste factors
Owen Sound WPCP	0.84	0.85	2	3	$FeCl_3$	8.0	7.9	1.05:1	0.9:1	Adequate chemical dosage		
Parry Sound WPCP	0.86	0.56	4	0	$FeCl_3$	3.8	4.5	0.53:1	0.82:1	Low clarifier surface loading	Good sludge settleability	Good dosage control
Port Elgin WPCP	1.93	1.56	11	11	Installed in 1986	--	--	--	--	No chemicals added		
Sault Ste. Marie WPCP	4.61	4.23	12	12	No chemicals used	--	--	--	--	No chemicals added		
Sturgeon Falls WPCP	0.33	0.46	0	0/10	$FeCl_2/FeCl_3$ 50/50	3.3	3.9	0.62:1	0.63:1	No industrial wastes	Low influent P concentration	Superior plant operation
Sudbury WPCP	1.84	2.10	12	12	Installed in 1986	--	--	--	--	No chemicals added		
Thunder Bay WPCP	1.27	1.01	10	4	$FeCl_3$	17.3	15.8	2.5:1	2.5:1	High clarifier surface loading		
Hamner, Val-Caron, Val-Therese WPCP (Valley East)	1.14	0.69	5	0	$FeCl_2/FeCl_3$ 50/50	10.3	8.4	1:1	0.89:1			
Mikkola WPCP (Walden)	2.34	2.66	12	12	No chemicals used	--	--	--	--	No chemicals added		
Walkerton WPCP	0.99	0.90	4	5	Alum (to 1985) $FeCl_3$ (1985-)	--	6.7	--	0.4:1	Low clarifier surface loading	Good dosage control	Superior plant operation
Wasaga Beach WPCP	--	--	--	--	--	--	--	--	--	No chemical addition		

Note: Elliot Lake Plant 2 was not operational in 1984 or 1985.

TABLE 30. PHASE 2 WPCPs DEMONSTRATING SUPERIOR PERFORMANCE

PLANT	BASIN	PLANT TYPE	EFFLUENT TP (mg/L)		NO. OF MONTHS OUT OF COMPLIANCE ('84 & '85)	FLOW (10^3 m^3)			COMMENT
			1984	1985		DESIGN	1984	1985	
1. Port Dalhousie WPCP (St. Catharines)	Ontario	CAS	0.54	0.39	0	61.4	32.4	41.6	64% of Design Flow
2. Fergus WPCP	Erie	CAS	0.64	0.55	0	5.0	3.2	3.9	78% of Design Flow
3. Port Hope WPCP	Ontario	HRAS	0.53	0.56	0	9.1	8.4	9.6	Inf. TP 3.6 mg/L
4. Trenton WPCP	Ontario	CAS	0.58	0.67	1	15.9	10.8	11.2	0.5 mg/L Summer Requirement
5. Midland WPCP	Huron	CAS	0.56	0.57	1	13.6	9.2	10.9	81% of Design Flow

TABLE 31. PHASE 2 WPCPs NOT CONSISTENTLY COMPLYING WITH TP GUIDELINES

PLANT	BASIN	PLANT TYPE	EFFLUENT TP (mg/L)		NO. OF MONTHS OUT OF COMPLIANCE ('84 & '85)	FLOW (10^3 m^3)			COMMENT
			1984	1985		DESIGN	1984	1985	
1. Collingwood WPCP	UGL	CAS	1.49	1.92	18	24.5	17.4	18.5	Influent TP > 10 mg/L
2. Humber WPCP (Metro Toronto)	Ontario	CAS	1.43	1.08	16	409.14	339.6	378.1	Influent TP 8-10 mg/L
3. Esten Lake WPCP (Elliot Lake)	UGL	CAS	1.33	1.10	13	13.0	10.9	12.5	On-Line Dose Control
4. Moore (Corunna) WPCP	Erie	EA	0.87	0.85	12	4.5	1.4	2.9	Inconsistent Performance
5. St. Thomas WPCP	Erie	CAS	1.20	1.14	11	40.9	18.5	18.9	< 50% Design Flow
6. Main WPCP (Metro Toronto)	Ontario	CAS	0.97	1.09	11	818.28	677.3	683.8	Inconsistent Performance
7. Duffin Creek WPCP	Ontario	CAS	0.98	1.05	9	181.8	121.1	150.0	Inconsistent Performance

identify the plants selected for the Phase 2 program. Also included for each plant are drainage basin, plant type, effluent TP concentrations and compliance data for 1984 and 1985, design and 1984/1985 flows, and comments related to plant performance.

3.2.2 Program Description

Each of the twelve facilities was monitored for a period of four to six weeks during summer and fall 1986 to confirm the historical performance data, establish chemical dosage information and assess operational practices and design factors which influenced phosphorus removal. The monitoring program at each plant was tailored for that specific facility but generally involved the collection of twenty-four hour composite samples of raw wastewater and primary effluent, and twenty-four hour flow-proportioned samples of secondary effluent. In addition, key operation information such as chemical dosage, organic loading, SRT, F/M ratio and flow (average and peak) were collected to allow a thorough operational assessment of the plant.

Specific details of the monitoring conducted at each facility, along with plant design information and detailed monitoring results, were presented in the Phase 2 report(2).

3.2.3 Monitoring Results

Table 32 presents a summary of the 5-year (1981-1985) and 1985 averages compared to the Phase 2 period averages for flow, and influent and effluent quality (BOD, TSS and TP) for each plant involved in the Phase 2 program.

In general, effluent BOD_5 concentrations for all plants were reported much lower for the sampling period (by CANVIRO) than historically (by MOE). This discrepancy may be a result of the different methodologies used for measuring BOD_5 at the MOE laboratory and at CANVIRO. At CANVIRO, inhibited BOD_5 tests were conducted which measured only the carbonaceous component of the biochemical oxygen demand. At MOE, uninhibited BOD_5 tests are conducted, measuring total (carbonaceous plus nitrogenous) BOD_5. Many of the plants had slightly lower influent BOD_5 concentrations than historically

TABLE 32. COMPARISON OF SAMPLING PERIOD PERFORMANCE TO HISTORICAL PERFORMANCE

PLANT	DESIGN FLOW (10^3 m^3/d)	1981-1985 AVERAGE							1985 AVERAGE							SAMPLING PERIOD AVERAGE						
		FLOW (10^3 m^3/d)	INFLUENT			EFFLUENT			FLOW (10^3 m^3/d)	INFLUENT			EFFLUENT			FLOW (10^3 m^3/d)	INFLUENT			EFFLUENT		
			BOD	TSS	TP	BOD	TSS	TP		BOD	TSS	TP	BOD	TSS	TP		BOD	TSS	TP	BOD	TSS	TP
Port Dalhousie WPCP*	61.3	36.5	107	102	4.2	7.9	8.4	0.55	41.6	128	118	3.9	11.5	10.6	0.39	49.2	44	69	3.1	3.5	10.0	0.77
Fergus WPCP*	5.00	3.42	118	231	5.8	8.9	17.4	0.63	3.88	120	132	4.9	10.2	24.5	0.55	3.70	73	171	3.8	4.6	12.6	0.59
Midland WPCP*	13.6	9.25	76	175	13.0	8.2	6.3	0.48	10.9	68	132	4.5	3.0	6.4	0.57	10.4	55	164	5.8	2.6	6.2	0.69
Collingwood WPCP†	24.5	16.8	170	151	7.8	9.2	13.3	1.42	18.5	163	131	11.2	5.8	12.6	1.92	17.4	145	178	13.7	1.7	7.0	1.50
Moore Twp. WPCP†	1.45	2.05	115	122	7.0	6.4	9.9	0.85	2.85	124	138	7.9	9.1	9.6	0.85	2.41	77	120	5.2	2.3	7.0	0.60
St. Thomas WPCP†	26.8	17.8	80	121	4.6	7.1	22.7	1.15	18.9	89	145	5.2	6.4	8.3	1.14	21.1	78	160	4.9	2.2	7.0	0.75
Humber WPCP†	409.1	371.6	266	362	9.6	13.9	22.0	1.26	378.1	264	326	8.9	11.5	18.2	1.08	415.5	190	222	8.7	10.5	55	1.24
Main WPCP†	818.3	712.0	202	223	6.0	14.7	15.1	0.93	683.8	167	196	5.9	22.3	26.0	1.09	1262	87	177	5.5	5.7	58	2.01
Duffin Creek WPCP†	189.3	97.5	165	244	7.1	15.7	17.5	1.30	150.0	144	251	6.1	14.3	15.6	1.05	186.9	98	234	7.1	6.3	12.1	1.27
Port Hope WPCP*	9.08	8.01	93	78	3.5	5.5	5.8	0.64	9.59	111	57	1.9	6.0	5.4	0.56	9.64	26	47	2.9	3.0	6.8	<0.87
Trenton WPCP*	15.9	10.5	181	166	5.8	12.6	11.7	0.78	11.2	235	176	6.1	10.8	13.0	0.67	17.2	93	92	3.5	5.8	48	1.29
Esten Lake WPCP†	16.0	10.4	110	118	3.6	12.6	12.4	0.97	12.5	87	117	4.9	15.3	15.9	1.10	8.49	46	50	3.1	4.0	8.0	0.82

* Plants historically demonstrating good phosphorus removal performance.

† Plants historically demonstrating poor phosphorus removal performance.

reported. This was undoubtedly the effect of raw wastewater dilution resulting from the frequent and heavy rainfall that occurred during the months of August and September 1986.

The high effluent quality reported historically, in terms of BOD_5, suspended solids and total phosphorus, was confirmed at Port Dalhousie WPCP, Fergus WPCP, Midland WPCP and Port Hope WPCP. At Trenton WPCP, the effluent quality, in terms of suspended solids and phosphorus, was much poorer than historically reported despite the weak influent concentrations of these parameters for this period. The weak influent and poor performance were probably due to the heavy rainfall during the sampling period, resulting in a high secondary clarifier surface load and a large amount of solids carryover.

The poor phosphorus removal performance historically reported for Collingwood WPCP, Duffin Creek WPCP, Humber WPCP and Main WPCP was confirmed by the results from the sampling program. At Humber WPCP and Main WPCP, effluent quality, in terms of suspended solids and phosphorus, was noticeably worse during the sampling period than historically reported. The large amount of precipitation during the sampling period contributed to atypical plant operation.

The Moore Township WPCP, St. Thomas WPCP and Esten Lake WPCP, which had had difficulties in consistently achieving an effluent TP concentration of 1 mg/L, were found to perform better during the Phase 2 sampling than historically reported.

At Esten Lake, improved phosphorus removal performance was due to the elimination of previous problems associated with alum dosing equipment and with sludge haulage and storage. Also, the recent addition of an online ortho-phosphate analyzer allowed better control of alum dosage.

Improved performance at the Moore Township and St. Thomas WPCPs was attributable to several factors including recent increase in chemical dosages at both plants and better overall plant operation. In addition, the Phase 2 sampling program produced substantially more effluent quality data on which to characterize plant performance than typically reported for these two facilities. In these cases, it was considered that the apparent improvement in plant performance was at least partially due to better characterization of the effluent quality resulting from increased sampling frequency.

3.2.4 Factors Contributing to Superior Phosphorus Removal Performance

Table 33 presents a summary of key operational and performance parameters at the five Phase 2 WPCPs that had consistently achieved 1 mg/L effluent TP concentrations on a monthly basis in 1984 and 1985.

Plants using ferric chloride, ferrous chloride and alum were represented and the chemical dosages (metal basis) ranged from as low as 2.4 mg/L to 6.8 mg/L. Hydraulic loadings at these facilities ranged from about 75 percent of design to more than 100 percent of design. At all five plants, the ratio of metal dosage to soluble phosphorus concentration in the primary effluent was 1.5 or higher on a molar basis. As a result, each of the plants was able to achieve soluble phosphorus concentrations of less than approximately 0.5 mg/L in the secondary effluent. Secondary clarifier surface loadings at the Port Dalhousie WPCP, Fergus WPCP, Midland WPCP and the new component of the Port Hope WPCP were less than 20 $m^3/m^2 \cdot d$, resulting in low effluent suspended solids concentrations (less than 12 mg/L) and low particulate phosphorus concentrations.

Of these five WPCPs, only Trenton failed to achieve 1 mg/L effluent TP. High flows produced by extreme rainfall conditions resulted in abnormal clarifier surface loadings and high effluent suspended solids concentrations. The high particulate phosphorus contribution from these effluent solids resulted in poor phosphorus removal performance during the Phase 2 monitoring period.

3.2.5 Factors Contributing to Poor Phosphorus Removal Performance

Table 34 presents a summary of the factors that affected the phosphorus removal performance during the Phase 2 program at the historically non-complying plants.

Data acquired at the St. Thomas, Moore Township and Esten Lake WPCPs demonstrated that compliance could be achieved at these facilities by increasing chemical dosage, improving dosage control and resolving sludge management problems. At the St. Thomas and Moore Township plants, the molar metal-to-soluble phosphorus ratio was maintained at a 2.0 or higher, producing low soluble phosphorus concentrations (0.55 mg/L and 0.3 mg/L, respectively).

TABLE 33. SUMMARY OF KEY FACTORS CONTRIBUTING TO EFFICIENT PHOSPHORUS REMOVAL

PLANT	% OF DESIGN FLOW	SECONDARY CLARIFIER SURFACE LOADING ($m^3/m^2.d$)	INFLUENT		CHEMICAL ADDITION			EFFLUENT			
			TP	SOL.P	TYPE	DOSAGE (mg/L)	METAL:SOL.P (Mole/Mole)	TSS (mg/L)	TP (mg/L)	SOL.P (mg/L)	PART.P (mg/L)
Pt. Dalhousie WPCP	75	15.3	3.1	2.1	$FeCl_3$	6.8	2.9	10.0	0.77	0.50	0.27
Fergus WPCP	74	16.3	3.8	2.1	$FeCl_2$	4.7	1.8	12.1	0.59	0.42	0.17
Midland WPCP	76	7.5	5.8	2.6	$FeCl_3$	3.7	1.5	6.2	0.69	0.54	0.16
Port Hope WPCP	106	31.2(old), 18.1(new)	2.9	2.0	Alum	2.4	1.5	6.8	<0.87	<0.39	I.D.
Trenton WPCP	110	42.4	3.5	2.0	$FeCl_2$	6.2	2.5	48	1.29	0.41	0.88

I.D. = Insufficient Data

TABLE 34. SUMMARY OF KEY FACTORS CONTRIBUTING TO INEFFICIENT PHOSPHORUS REMOVAL

PLANT	% OF DESIGN FLOW	SECONDARY CLARIFIER SURFACE LOADING ($m^3/m^2.d$)	INFLUENT		CHEMICAL ADDITION			EFFLUENT			
			TP	SOL.P	USED	DOSAGE (mg/L)	METAL:SOL.P (Mole/Mole)	TSS (mg/L)	TP (mg/L)	SOL.P (mg/L)	PART.P (mg/L)
Collingwood WPCP	71	11.7	13.7	10.6	Alum	8.1	0.9	7.0	1.48	1.00	0.38
Moore Twp. WPCP	166	11.8	5.2	3.6	Alum	7.1	2.4	7.0	0.60	0.30	0.30
St. Thomas WPCP	79	Avg. 22.6	4.9	2.3	Alum	3.6	2.0	6.5	0.75	0.55	0.20
Humber WPCP	102	22.8	8.7	2.9	$FeCl_2$	5.5	1.2	55	1.24	0.47	0.77
Main WPCP	154	62.9	5.5	2.4	$FeCl_2$	4.2	1.8	58	2.01	<0.27	1.74
Duffin Creek WPCP	98	17.4	7.1	2.7	Alum	2.8	1.3	12.1	1.27	0.73	0.54
Esten Lake WPCP	53	7.8	3.1	<2.0	Alum	1.6	1.1	8.0	0.82	0.54	0.28

At the Collingwood WPCP and Duffin Creek WPCP, poor phosphorus removal performance was related to high effluent soluble phosphorus concentrations (1.00 mg/L and 0.73 mg/L, respectively). In both cases, these high concentrations of soluble phosphorus in the plant effluents resulted from low molar metal-to-soluble phosphorus ratios (0.9 at Collingwood and 1.3 at Duffin Creek). At Collingwood, the low ratio was due to high influent soluble phosphorus concentrations (10.6 mg/L). At Duffin Creek, the low ratio was due to low chemical dosage (2.8 mg Al/L). Thus neither plant was capable of achieving the effluent limit of 1 mg/L despite low secondary clarifier loadings and acceptable effluent suspended solids concentrations. Both of these plants had been using higher priced alum for phosphorus precipitation.

At the two Toronto plants (Main and Humber), chemical dosage was sufficient to achieve soluble phosphorus concentrations of less than 0.5 mg/L. At the Main plant, extremely high clarifier surface loadings (62.9 $m^3/m^2 \cdot d$), resulting from heavy rainfall, caused solids carryover and average effluent suspended solids and particulate phosphorus concentrations of 55 mg/L and 1.74 mg/L, respectively. At the Humber plant, a solids washout problem was also evident, causing high effluent suspended solids (55 mg/L) and particulate phosphorus (0.77 mg/L). However, the secondary clarifiers were not hydraulically loaded to the extent of those at the Main WPCP. It appeared that a combination of factors other than chemical dosage inadequacies have contributed to the phosphorus removal performance problems at the Main and Humber WPCPs.

3.3 Phase 3 Program Results

3.3.1 Program Description

The results of the Phase 1 and Phase 2 investigations, as well as previous experience in phosphorus removal assessments(4), showed that the most significant factor contributing to consistent non-compliance with effluent phosphorus limits was inadequate chemical dosage. Inadequate sludge management practices and high clarifier surface loadings were identified as secondary factors contributing to plant non-compliance; however, in some cases, high chemical dosage could effectively compensate for problems related to poor sludge management or high hydraulic loading.

The overall objective of the Phase 3 program was to demonstrate that phosphorus removal performance could be upgraded by low capital cost operational changes, in most cases. Four plants were selected for more detailed assessment in Phase 3 - Collingwood WPCP, Duffin Creek WPCP, Toronto Humber WPCP, and Toronto Main WPCP. Collingwood and Duffin Creek WPCPs were included in Phase 3 because the Phase 2 data suggested that improvements in phosphorus removal performance could be achieved at these plants. The Toronto Humber and Toronto Main WPCPs were included in Phase 3 because of the magnitude of their phosphorus loading contribution to the Great Lakes Basin.

The investigations conducted at the Collingwood WPCP and Duffin Creek WPCP were similar in that operational changes had been made at the plants subsequent to the Phase 2 investigations to correct chemical dosage inadequacies. The Phase 3 program at both of these facilities involved extended monitoring of plant performance and optimization of operating conditions to document the success of these operational changes.

The Phase 2 studies at the two Toronto plants (Main and Humber) were conducted during periods of high flow due to abnormally high precipitation. Therefore, these results were not considered to be typical of plant performance under normal flow conditions and did not conclusively identify the long-term problems at these plants which prevented consistent compliance with the 1 mg/L effluent total phosphorus limit. Thus, the Phase 3 evaluations at these plants focussed on an intensive analysis of historic plant operating and performance data.

Detailed descriptions of the field evaluations conducted at the Collingwood and Duffin Creek WPCPs and the data analysis undertaken for the Main and Humber WPCPs are presented in the Phase 3 report[3].

3.3.2 Collingwood WPCP

3.3.2.1 Approach

Three major industries in the Town of Collingwood had been identified as being major contributors to the treatment facility - a starch plant (7 percent of hydraulic load), a glass manufacturing plant (9 percent of hydraulic load) and a distillery (8 percent of hydraulic load). Two of these industries had been identified as also being major sources of phosphorus,

based on town sewer monitoring programs - the starch plant during production of phosphorylated starches and the glass plant from glass washing operations. A significant fraction of the WPCP phosphorus loading was attributable to these sources. In the late fall of 1986, the two large industrial contributors began to initiate in-house steps to reduce phosphorus discharges to the sanitary sewer at the direction of the Town of Collingwood.

As town staff had already initiated measures to reduce the influent phosphorus concentrations to more typical levels, a Phase 3 monitoring program was initiated to optimize chemical dosage and document that an effluent total phosphorus concentration of less than 1 mg/L could be achieved on a consistent basis.

3.3.2.2 Results

Results of Phase 2 and Phase 3 raw sewage samplings are compared in Table 35 in terms of concentrations of total and filtered phosphorus, suspended solids and BOD_5. Waste strength, in terms of all parameters, was lower during the Phase 3 program than during the Phase 2 program. The average daily flow during Phase 3 was 16,500 m^3/d, compared to 17,440 m^3/d during Phase 2. Dilution due to rainfall and spring runoff during Phase 3 does not appear to be a significant contributor to the reduction in sewage strength as flows during the two sampling periods were comparable. The in-plant measures instituted by the large industrial contributors to reduce phosphorus discharges may have also reduced discharges of BOD_5 and suspended solids. The industrial phosphorus discharge control program had a marked effect on influent phosphorus concentrations at the plant. The concentration measured during Phase 3 was only 36 percent of that experienced during the Phase 2 monitoring period.

Final effluent quality during Phase 3 is presented in Table 36. Effluent BOD_5 was consistently less than 25 mg/L and averaged approximately 5 mg/L. Final effluent suspended solids were high compared to historical data, averaging 16.6 mg/L. The high average TSS concentration relates to two plant upsets, which occurred on March 2 and March 31. The average final effluent total phosphorus concentration was less than 0.50 mg/L over the Phase 3 monitoring period despite the upset event on March 31 when the total phosphorus

TABLE 35. COMPARISON OF RAW SEWAGE QUALITY DURING PHASE 2 AND PHASE 3 MONITORING AT COLLINGWOOD WPCP

	BOD_5 (mg/L)	TSS (mg/L)	PHOSPHORUS (mg/L)	
			TOTAL	SOLUBLE
Phase 2 *	145	178	13.7	10.6
Phase 3 **	120	106	4.9	3.3

* Based on 11 sampling days between June 18 and July 15, 1986.

** Based on sampling period between February 1 and March 31, 1987 (BOD_5 - 20 samples; TSS - 36 samples; phosphorus - 11 samples).

concentration was 3.8 mg/L due to the suspended solids carryover. The 90 percentile concentration for the period February/March was 0.95 mg/L, according to the probability distribution presented in Figure 9.

The average alum dosage during this monitoring period was 7.4 mg/L Al, comparable to the estimated dosage of 8 mg/L during Phase 2. However, the molar metal to soluble phosphorus dosage (Al:P) ratio averaged 4.23 during Phase 3 compared to 0.94 during Phase 2 as a result of the dramatic reduction in influent phosphorus loading. Under these dosage conditions, virtually complete precipitation of phosphorus was achieved. The soluble phosphorus concentration in the final effluent never exceeded the analytical method detection limit (typically 0.3 mg/L for the sample volume available).

3.3.3 Duffin Creek WPCP

3.3.3.1 Approach

Based on Phase 2 monitoring program results, it was determined that insufficient alum dosage was the principal factor contributing to inconsistent phosphorus removal performance at the Duffin Creek WPCP. The results obtained showed, at an alum dosage rate of 3 mg Al/L, that the ratio of

TABLE 36. FINAL EFFLUENT QUALITY DURING PHASE 3 AT DUFFIN CREEK WPCP

DATE	FINAL EFFLUENT CONCENTRATION (mg/L)		
	BOD_5	TSS	TOTAL P
Feb 2	3	8	
3	4	12	0.31
4		11	
5	5	19	
6	4		
9	18		
10		12	
11		4	
12	3	18	
13	4	3	0.40
16	1	9	
17	1	4	<0.23
18	6	3	<0.23
19	1	5	<0.24
20	2	11	<0.23
23	5	14	
24	6	23	0.82
25	4	24	1.20
26	5	7	0.34
Mar 2	7	50*	
3	9	22	0.68
4	15	26	0.48
5	8		<0.30
10	5	26	0.30
11	5	10	0.24
12	5	9	<0.25
13	2	11	<0.30
16	2	5	<0.23
17	2	10	<0.23
18	2	5	<0.23
19	1	11	<0.23
20	1	8	0.28
23	2	2	0.24
24	3	33	0.66
25	2	12	<0.26
26		10	
27	1	4	<0.23
31	17	142**	3.80
Apr 1	2	-	0.29
AVERAGE	4.6	16.6	<0.49

*Mechanical flow distribution problem
**High flow event

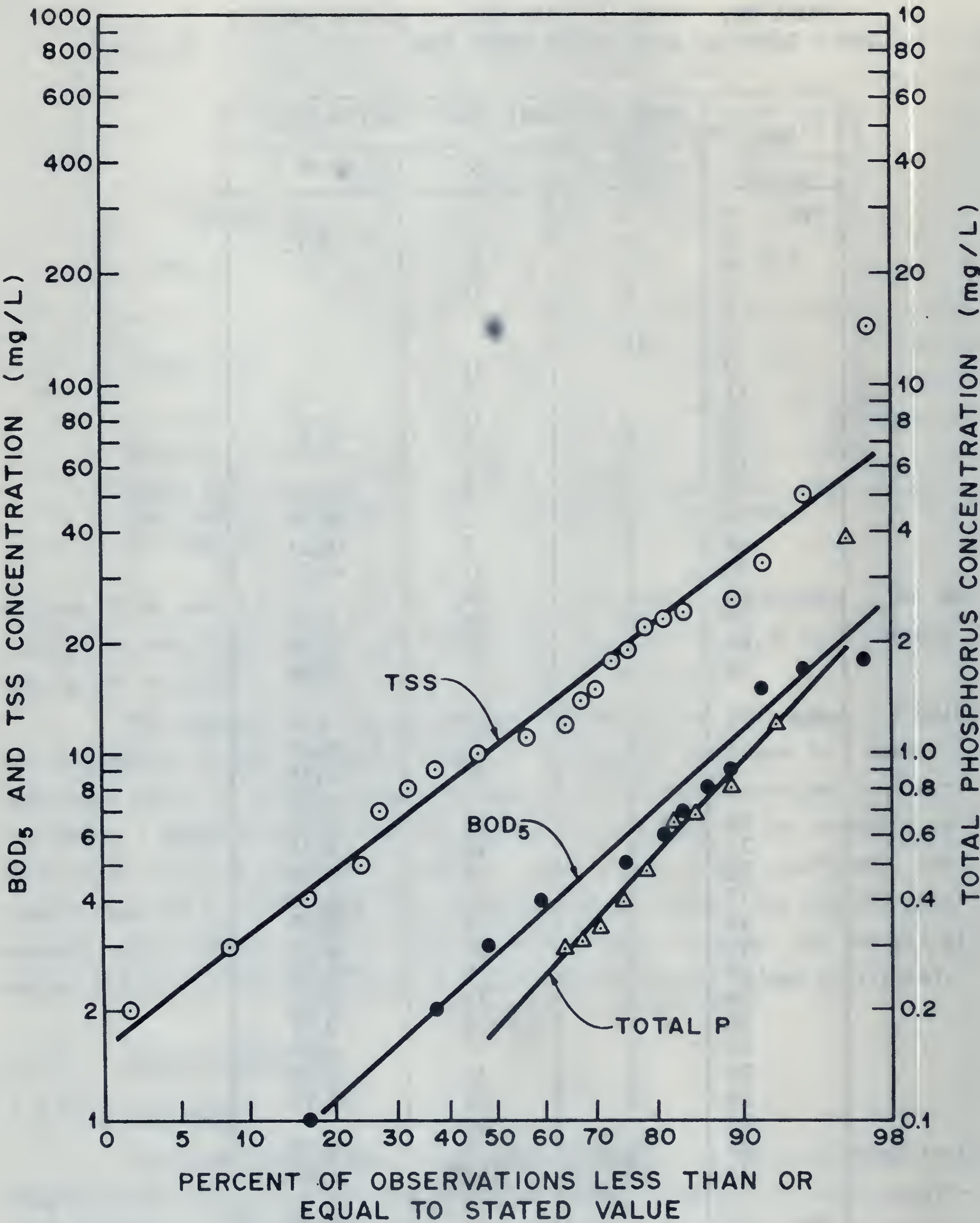

FIGURE 9: FREQUENCY DISTRIBUTION OF EFFLUENT QUALITY

aluminum to soluble phosphorus (in the primary effluent) was just equal to or less than that required for 75 percent removal of soluble phosphorus. After completion of the Phase 2 program, staff at the Duffin Creek WPCP changed the phosphorus removal chemical from alum to ferrous sulphate. Because ferrous sulphate was considerably less expensive than alum, chemical dosages at the plant were increased significantly at the same time. Phase 3 monitoring at the Duffin Creek WPCP was initiated to confirm the effectiveness of ferrous sulphate to maintain effluent phosphorus levels at less than 1 mg/L.

3.3.3.2 Results

Ferrous sulphate addition commenced in September 1986. Table 37 summarizes plant performance for the three month period following the change-over from alum to ferrous sulphate. The average flow during the last quarter of 1986 was 186,162 m^3/d, which was slightly lower than the average flow for the Phase 2 monitoring period. Raw sewage quality during October, November and December was similar to that observed previously, although TSS appeared to be higher and total phosphorus appeared to be lower than usual. Secondary effluent, in terms of TSS, was consistent with typical plant performance.

TABLE 37. MONTHLY PLANT PERFORMANCE AFTER IMPLEMENTATION OF FERROUS SULPHATE ADDITION

PARAMETER		MONTH			OVERALL AVERAGE
		OCTOBER	NOVEMBER	DECEMBER	
Flow (m^3/d)		184,047	153,880	179,100	186,162
Raw Sewage					
TSS (mg/L)	West	212	370	361	318
	East	189	374	218	267
Total P (mg/L)	West	4.2	7.3	4.3	5.7
	East	3.9	6.7	2.9	4.8
Secondary Effluent					
TSS (mg/L)	West	23	12	10	14.8
	East	22	11	10	14.4
Total P (mg/L)	West	1.13	0.70	0.45	0.75
	East	1.55	0.53	0.40	0.81

Of particular interest was the significant reduction in secondary effluent total phosphorus concentrations between October and December. In October, total phosphorus levels averaged 1.13 mg/L and 1.55 mg/L for the west and east sides, respectively, which represented typical effluent concentrations. In December, however, the levels dropped to 0.45 mg/L and 0.40 mg/L for the west and east sides, respectively. The average ferrous sulphate dosages for December were 10.3 mg Fe/L and 7.0 mg Fe/L, for the west and east plants, respectively. Alum dosages typically applied at the plant had been approximately 3 mg Al/L.

Table 38 presents a summary of influent, primary effluent and secondary effluent quality for January through April 1987 when Phase 3 monitoring was being conducted at the Duffin Creek WPCP.

TABLE 38. SUMMARY OF PERFORMANCE MONITORING DATA FOR DUFFIN CREEK WPCP

STREAM	AVERAGE CONCENTRATIONS (mg/L)			
	BOD_5	TSS	TOTAL P	SOLUBLE P
West Plant				
Raw	156	241	5.91	-
Primary	-	-	4.42	1.33 (3)
Secondary: flow-prop. (1)	-	-	0.33	0.26
composite (2)	22	14	0.48	0.24
East Plant				
Raw	147	239	5.88	-
Primary	-	-	4.83	1.93 (3)
Secondary: flow-prop. (1)	-	-	0.54	0.38
composite (2)	22	14	0.64	0.40

Notes: (1) Results based on flow-proportioned samples collected during the Phase 3 monitoring period from February 5 to March 27, 1987.

(2) Results based on plant performance records for January, February, March and April 1987.

(3) Does not include results for January 1987.

Average phosphorus concentrations in the secondary effluents from both the west and east plants were lower than levels previously recorded. Comparison of the flow-proportional total phosphorus concentrations of 0.33 mg/L and 0.54 mg/L obtained during Phase 3 monitoring for the west and east plants are 68 percent and 64 percent lower than total phosphorus results obtained during Phase 2. Similar results were observed for flow-proportional soluble phosphorus levels, which decreased by 55 percent for the west plant and 56 percent for the east plant. Secondary effluent composite total phosphorus levels for the period from January to April 1987 were low in comparison to historical values. Figures 10 and 11 present probability distributions for total phosphorus concentrations in the raw sewage, primary effluent and secondary effluent from the west and east sides of the Duffin Creek WPCP for the Phase 3 monitoring period. Chemical precipitation resulted in removal of 95 percent of total phosphorus and 80 percent of soluble phosphorus in secondary clarifiers on the west side of the plant. Total and soluble phosphorus removals for the east side of the plant, after chemical addition, were 89 percent and 80 percent, respectively, based on average results shown in Table 37 for composite samples of secondary effluent.

The average iron dosages applied to the west and east plants were 5.9 mg Fe/L and 6.1 mg Fe/L, respectively. The average molar ratio of iron to phosphorus on the west side of the plant was 1.5; average weight ratio of Fe:P for the west plant was 2.7. The relatively low average primary effluent soluble phosphorus concentrations coupled with the high Fe:P ratio resulted in low secondary effluent phosphorus levels. The average total phosphorus concentration in the secondary effluent from the west plant was 0.40 mg/L, with average soluble and particulate fractions of approximately 47 percent and 53 percent, respectively. The average molar ratio of Fe:P on the east side of the plant was 1.4. The average weight Fe:P ratio was 2.6. These ratios are not significantly different than those observed for the west plant. The average total phosphorus level in secondary effluent from the east plant was 0.60 mg/L, comprised of 0.36 mg/L soluble phosphorus and 0.24 mg/L particulate phosphorus.

The results obtained from the west and east plants, in terms of molar ratio of Fe:P and secondary effluent total phosphorus, appear to indicate that a molar ratio of 1.5 (Fe:P) would be sufficient to reduce the effluent total phosphorus concentrations to below the guideline level (1.0 mg/L) on a consistent basis.

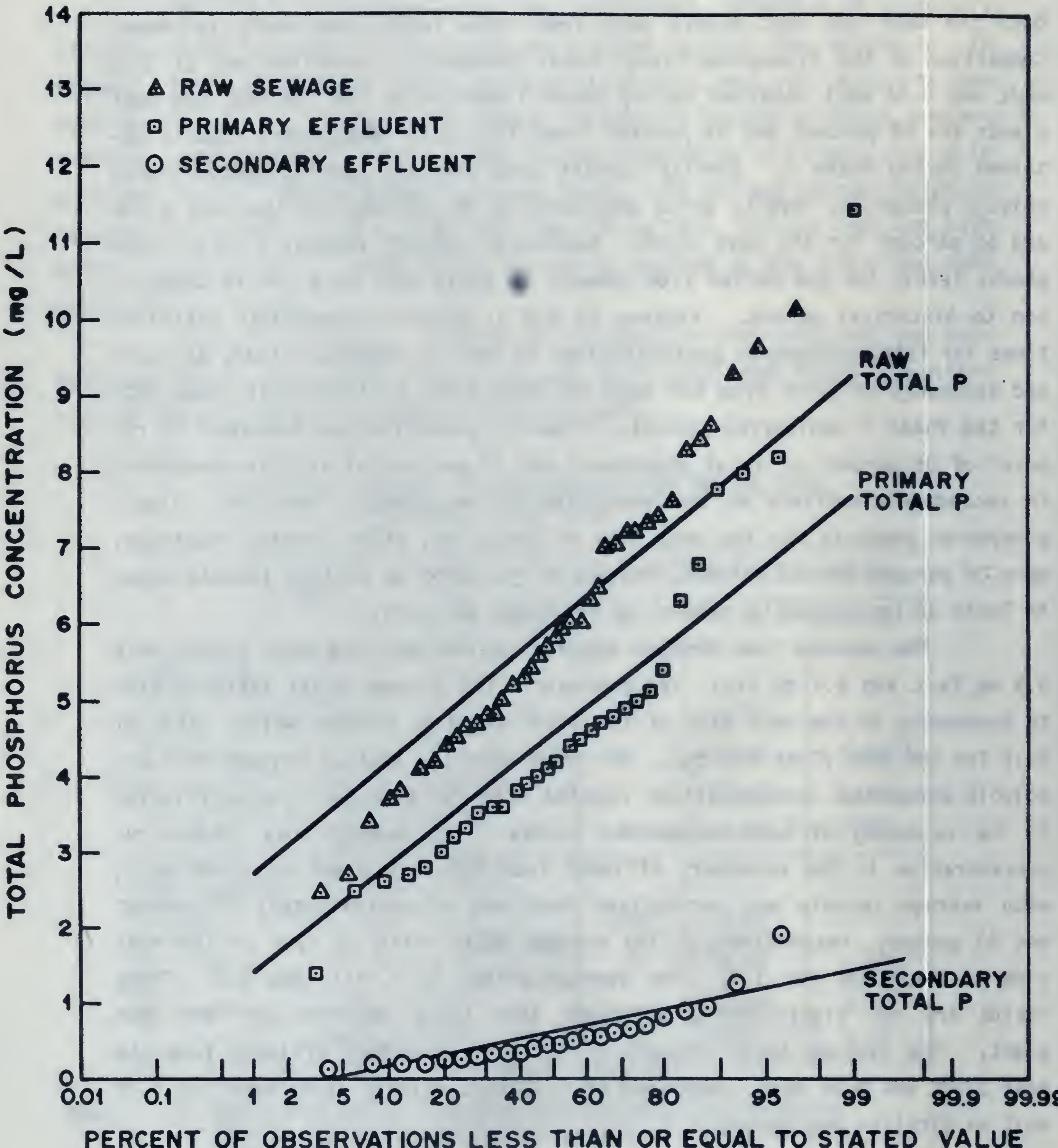

FIGURE 10 : DUFFIN CREEK WEST PLANT

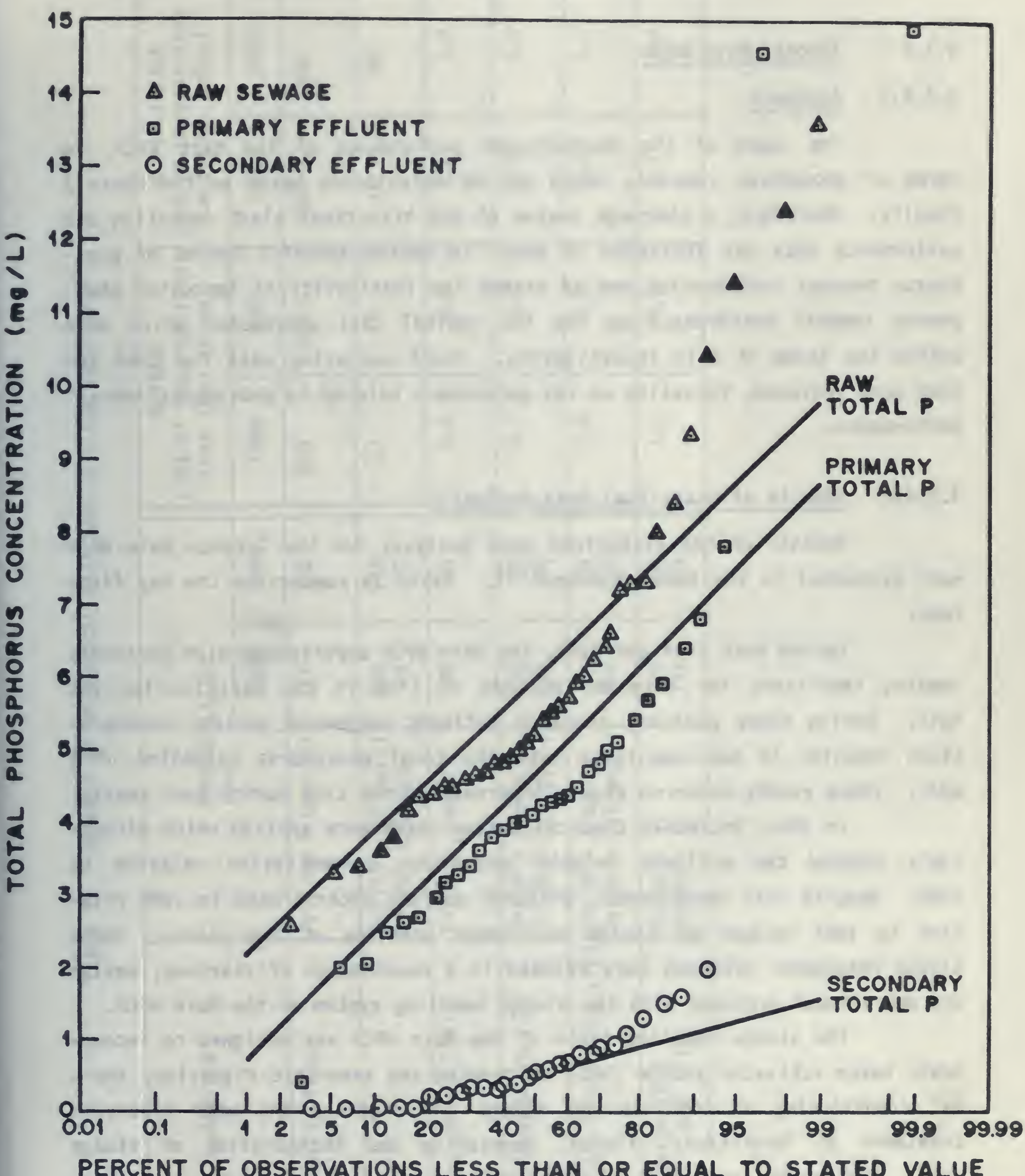

FIGURE 11 : DUFFIN CREEK EAST PLANT

3.3.4 Toronto Main WPCP

3.3.4.1 Approach

The cause of the inconsistent performance of the Main WPCP, in terms of phosphorus removal, could not be established based on the Phase 2 results. Therefore, a thorough review of the historical plant operating and performance data was initiated in order to define specific causes of phosphorus removal inadequacies and to assess the feasibility of improving phosphorus removal performance by the low capital cost approaches which were within the scope of this investigation. Plant operating data for 1984 and 1985 were reviewed, focussing on key parameters related to phosphorus removal performance.

3.3.4.2 Results of Historical Data Analysis

Details of the historical data analyses for the Toronto Main WPCP were presented in the Phase 3 report[3]. Table 39 summarizes the key findings.

During both 1984 and 1985, the Main WPCP experienced high hydraulic loading conditions for extended periods of time in the early spring and fall. During these periods, elevated effluent suspended solids concentrations resulted in non-compliance with the total phosphorus guideline of 1 mg/L. These events occurred about 15 percent of the time during both years.

In 1985, increased chemical dosage rates were applied which effectively reduced the effluent soluble phosphorus concentration relative to 1984. Despite this improvement, effluent quality deteriorated in 1985 relative to 1984 because of sludge management problems at the plant. These sludge management problems were related to a combination of start-up, design and operational problems with the sludge handling system at the Main WPCP.

The sludge handling train at the Main WPCP was designed to incorporate waste activated sludge (WAS) thickening and anaerobic digestion, thermal conditioning of combined raw sludge and digested WAS with anaerobic treatment of 'heat-treat' liquor, dewatering and incineration of sludge cake. The design concept is illustrated schematically in Figure 12. Components of this system have been brought online since December 1981 when the thermal conditioning unit was commissioned. The belt presses went into operation in February 1984. To date, plant staff have been unable to operate the

TABLE 39. SUMMARY OF HISTORICAL DATA ANALYSIS FOR MAIN WPCP

PARAMETER	PROBABILITIES (Pr)			MEDIAN (50% of Observations Less than Value)		90 PERCENTILE (90% of Observations Less than Value)	
		1985	1985	1984	1985	1984	1985
Average Daily Flow (10^3 m^3/d)	Pr(Flow > Design)	17%	13%	650	620	940	830
TSS (mg/L)	Pr(TSS > 15 mg/L) Pr(TSS >25 mg/L)	15% 6%	55% 25%	10	14	19	50
Total Phosphorus (TP) (mg/L)	Pr(TP > 1 mg/L)	30%	39%	0.8	0.8	1.6	1.6
Soluble Phosphorus (SP) (mg/L)	Pr(SP > 1 mg/L) Pr(SP > 0.5 mg/L)	5% 25%	1% 8%	0.3	0.2	0.8	0.4
Particulate Phosphorus (PP) (mg/L)	Pr(PP > 1 mg/L) Pr(PP > 0.5 mg/L)	4% 39%	15% 59%	0.4	0.6	0.8	1.2
Molar Dosage (MD) (Fe:Influent SP)	Pr(MD > 1) Pr(MD > 2)	75% 18%	98% 42%	1.6	1.8	2.3	3.0

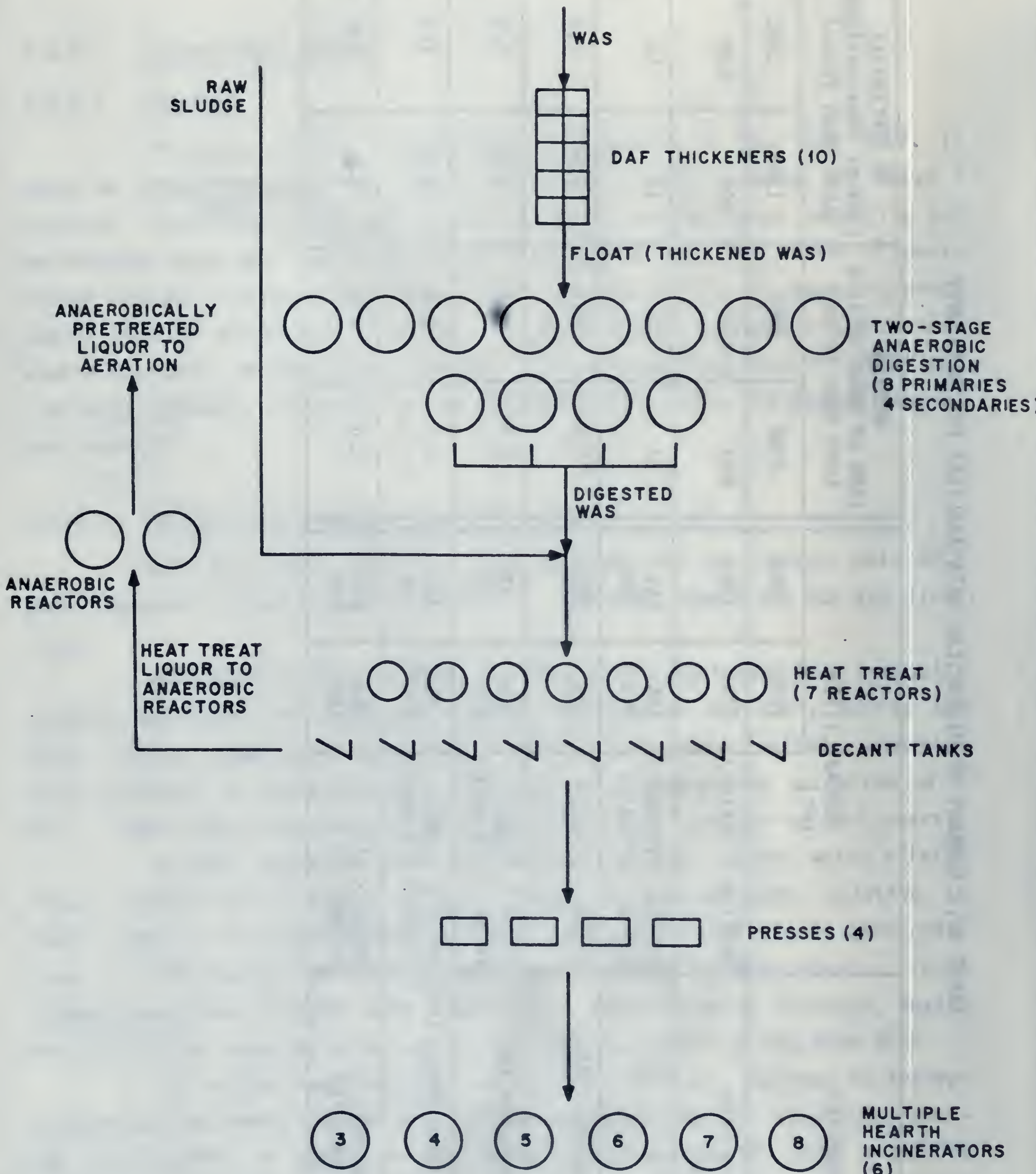

FIGURE 12 — SCHEMATIC FLOWSHEET OF MAIN WPCP SLUDGE HANDLING TRAIN AS DESIGNED

sludge handling train as designed due to a variety of problems. The present operating mode is illustrated schematically in Figure 13. Operation in this mode has resulted in process bottlenecks which have limited the system's ability to adequately handle the sludge generated at the plant.

At the present time, all sludge (thickened WAS and raw sludge) is being digested because of odour problems related to dewatering of thermally-conditioned, undigested raw sludge. Because the digestion system was intended to handle only WAS, it is overloaded. Supernatant quality is poor, which results in an additional solids load on the process. Furthermore, it was intended to utilize existing digesters for the 'heat-treat' liquor pretreatment process. This concentrated liquor is presently returned to the plant untreated, which applies an additional organic load on the system, further increasing solids generation in the biological process. Corrosion problems in the thermal conditioning decant tanks have limited system throughput. In addition, serious mechanical problems with the belt presses necessitated their removal and repair. As a result, existing coil filters and drum filters have been brought online for sludge dewatering. Sludge dewatered on the coil filters does not undergo thermal conditioning and, due to its higher moisture content, can be handled only in selected multiple hearth incinerators. Conveyor system design also produces a serious bottleneck in the incinerator feed because only some dewatering equipment and some incinerators can be operated at one time. The start-up problems with the belt presses were the single most serious sludge management problem in 1985. However, in a sludge management train as complex as that in use at the Main WPCP, operational or design problems in any component have serious ramifications to the operation of the entire plant.

Phosphorus removal inadequacies at the Main WPCP in 1984 and 1985 were related to excessive hydraulic loading conditions and to sludge management problems. Programs are already underway to rectify the sludge management problems at the plant. The 1984 and 1985 data suggest that operation of the plant at the chemical dosage applied in 1985 can overcome some of the hydraulic-related effluent suspended solids and total phosphorus excursions. The annual average effluent total phosphorus concentration for 1985, exclusive of data from periods of sludge management problems, would be approximately 0.8 mg/L. This average includes data from periods of high flow during spring 1985 and fall 1985, and compares to an annual average of 0.97 mg/L in

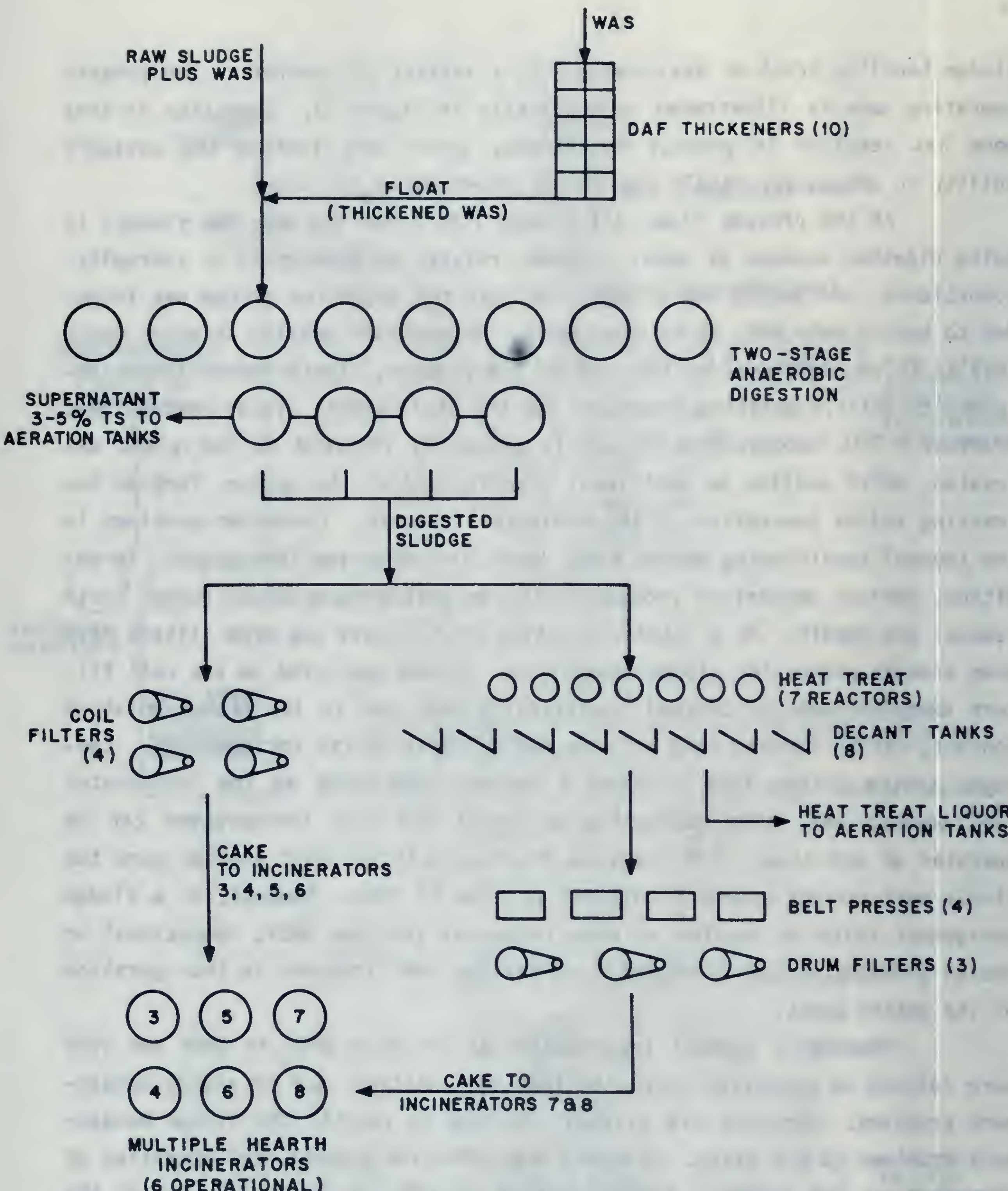

FIGURE 13 — SCHEMATIC FLOWSHEET OF MAIN WPCP SLUDGE HANDLING TRAIN AS OPERATED

1984 when sludge management problems were less of a factor but hydraulic loadings were similar. The factor contributing to the improvement from 0.97 mg/L to 0.8 mg/L was the reduction in the soluble phosphorus content of the effluent as a result of higher chemical dosage. This implies that the Main WPCP could comply with an annual average total phosphorus guideline of 1 mg/L, despite the hydraulic peaks, once the solids inventory control problems are resolved and if the plant continues to operate at the chemical dosage applied during 1985. However, during the months when hydraulic peaks occurred, compliance with a monthly average 1 mg/L total phosphorus guideline was not consistently achieved even at the higher chemical dosage. Consistent monthly compliance with a 1 mg/L effluent total phosphorus limit may necessitate reductions in extraneous flows to the plant and/or increased secondary clarification capacity.

3.3.5 Toronto Humber WPCP

3.3.5.1 Approach

An approach similar to that applied to the Main WPCP was applied in Phase 3 at the Humber WPCP. Historical plant operating and performance data for 1984 and 1985 were reviewed in detail to define specific causes of phosphorus removal inadequacies and to determine if low capital cost approaches to performance improvement were viable.

3.3.5.2 Results of Historical Data Analysis

Details of the historical data analysis for the Toronto Humber WPCP were presented in the Phase 3 report[3]. Table 40 summarizes the key findings.

Effluent quality, in terms of all parameters, improved at the plant from 1984 to 1985 despite an increase in plant hydraulic loading. Despite this improvement, effluent suspended solids exceeded 25 mg/L approximately 22 percent of the time and total phosphorus exceeded the objective of 1 mg/L approximately 40 percent of the time in 1985. Particulate phosphorus alone exceeded 1 mg/L almost 25 percent of the time in 1985, indicating that, regardless of the chemical dosage level, compliance with the effluent guideline would not be achieved on a consistent basis at the Humber WPCP. Chemical

TABLE 40. SUMMARY OF HISTORICAL DATA ANALYSIS FOR HUMBER WPCP

PARAMETER	PROBABILITIES (Pr)			MEDIAN (50% of Observations Less than Value)		90 PERCENTILE (90% of Observations Less than Value)	
		1985	1985	1984	1985	1984	1985
Average Daily Flow (10^3 m^3/d)	Pr(Flow > Design)	4%	12%	340	380	390	460
TSS (mg/L)	Pr(TSS > 15 mg/L) Pr(TSS > 25 mg/L)	68% 35%	53% 22%	20	17	46	33
Total Phosphorus (TP) (mg/L)	Pr(TP > 1 mg/L)	55%	40%	1.1	0.9	2.8	2.0
Soluble Phosphorus (SP) (mg/L)	Pr(SP > 1 mg/L) Pr(SP > 0.5 mg/L)	13% 25%	5% 16%	0.3	0.2	1.3	0.7
Particulate Phosphorus (PP) (mg/L)	Pr(PP > 1 mg/L) Pr(PP > 0.5 mg/L)	32% 78%	22% 55%	0.8	0.6	1.7	1.6
Molar Dosage (MD) (Fe:Influent SP)	Pr(MD > 1) Pr(MD > 2)	45%	75%	1.0	1.3	1.8	2.2

dosage increased in 1985 relative to 1984, which was largely responsible for the improvement in phosphorus removal performance achieved as soluble phosphorus levels in the effluent in 1985 exceeded 0.5 mg/L only 16 percent of the time and the median value was 0.2 mg/L. Despite this improvement, the plant was unable to comply with the total phosphorus effluent guideline on an annual or a monthly basis because of high effluent suspended solids concentrations. Further increases in chemical dosage would be ineffective in rectifying the problem which is associated with particulate phosphorus.

A review of aeration tank mixed liquor concentrations and effluent suspended solids concentration data for 1985 suggest a link between biological solids wastage problems and effluent quality similar to that identified at the Main WPCP.

The solids handling problems at the Humber WPCP are closely linked with those being experienced at the Main WPCP and discussed in Section 3.3.4. The sludge handling train at the Humber WPCP is shown schematically in Figure 14. Effective sludge management is predicated on the disposal of approximately 30 tonnes/day of dry solids from the Humber plant at the Main plant via the mid-Toronto interceptor. Residual sludge is disposed of, after dewatering, at the Brock Road landfill. Limited vehicles, long hauling distances and limited access hours presently restrict the quantity of sludge which can be disposed at the landfill. When sludge management system bottlenecks occurred at the Main WPCP, the operation of both Main and Humber were impacted.

Effluent quality problems at the Humber WPCP relate to sludge management problems. These problems are a direct result of the operating philosophy of utilizing the Main WPCP for disposal of the majority of sludge generated at the Humber plant and the problems being experienced at the Main plant with sludge disposal equipment. Long term remediation of the problem at the Humber plant is dependent on successful resolution of the Main plant sludge handling problems or development of sludge handling options for Humber which are independent of the Main plant.

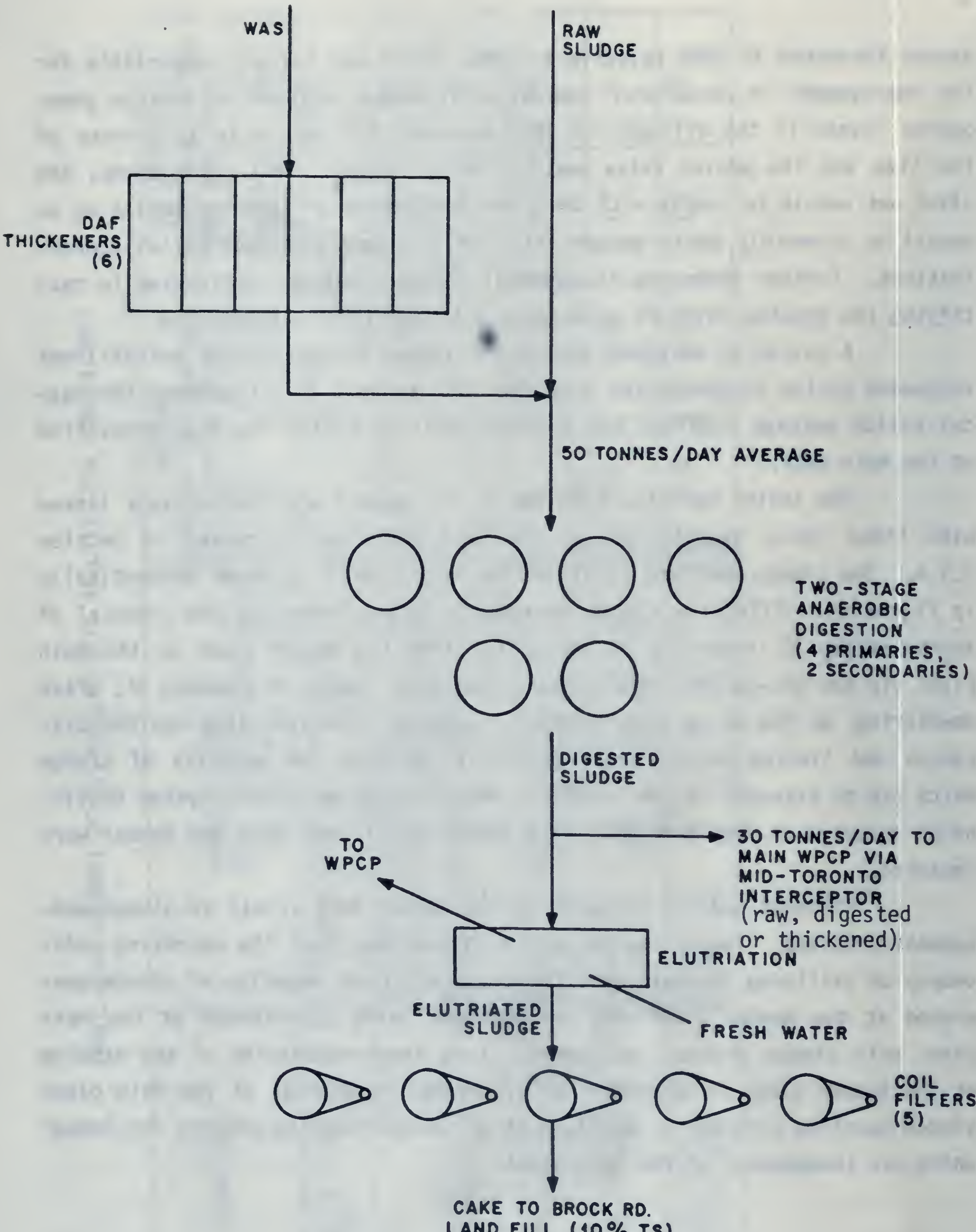

FIGURE 14 – SCHEMATIC FLOWSHEET OF HUMBER WPCP SLUDGE HANDLING TRAIN

3.4 Other Considerations

3.4.1 Effect of Sampling Frequency on Performance

WPCPs that sample and analyze effluent quality more frequently may be better able to control their chemical dosage and maintain the required effluent total phosphorus concentration. Compliance standards based on shorter-term time periods (i.e. monthly versus annual) necessitate better dosage control to ensure that the requirements are met consistently. To determine if effluent sampling frequency had an effect on annual average phosphorus concentration data for 1984 and 1985, the historical and plant survey information were reviewed.

Figure 15 illustrates the distribution of plants by the frequency of effluent sampling and analysis for phosphorus. About 24 plants (more than 24 percent) were not doing any effluent phosphorus sampling other than the required monthly (or bimonthly) analyses done at MOE laboratories. About 40 (more than 40 percent) of the plants were doing on-site analyses more than twice per week. Figures 16 and 17 compare the number of effluent samples taken in 1984 and 1985 at each plant to the annual average effluent TP concentration. Annual average effluent concentrations tend to deviate more from the ideal 1 mg/L when less than 50 samples (less than one sample per week) were taken. Where greater than 50 samples (more than one sample per week) were taken, there does not appear to be any trend of increased efficiency with an increased number of samples. The data suggest that sampling more than once per week reduces the variability of the effluent TP concentration. It also suggests that sampling more frequently than once per week may not result in a further improvement in effluent quality.

Other factors may also influence the sampling frequency and effluent quality relationship. If plant staff do not utilize the analytical data to adjust chemical dosage, then the frequency of sampling will not have an impact on effluent quality because it is not being utilized for control purposes. Sample type (grab or composite) and sample time will impact on the representativeness of the effluent quality data. The accuracy of the analytical methods used may also affect the result, as discussed in Section 3.4.2. It is apparent that more frequent sampling and analysis of effluent better characterizes the performance of a plant by avoiding overestimating or underestimating the impact of short-term upsets on average effluent quality.

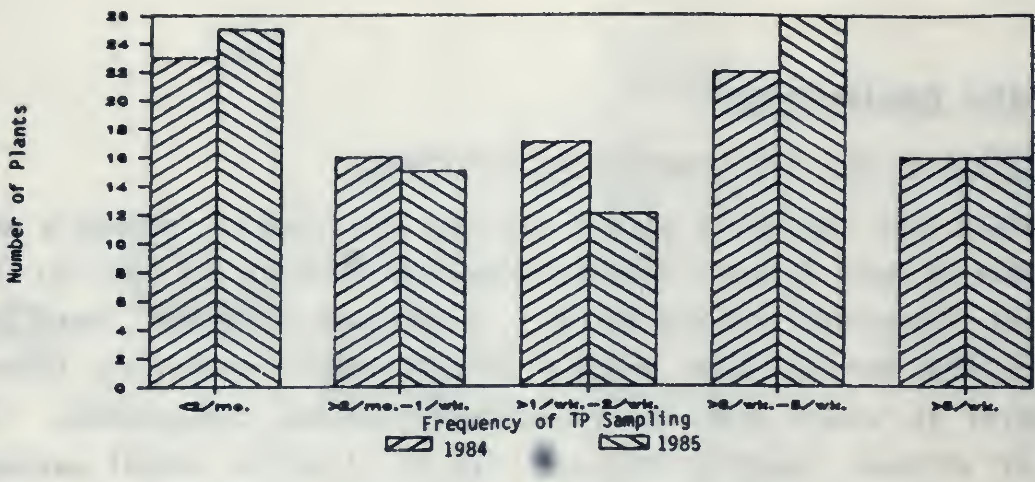

FIGURE 15 - SAMPLING FREQUENCIES FOR 96 PLANTS IN ONTARIO

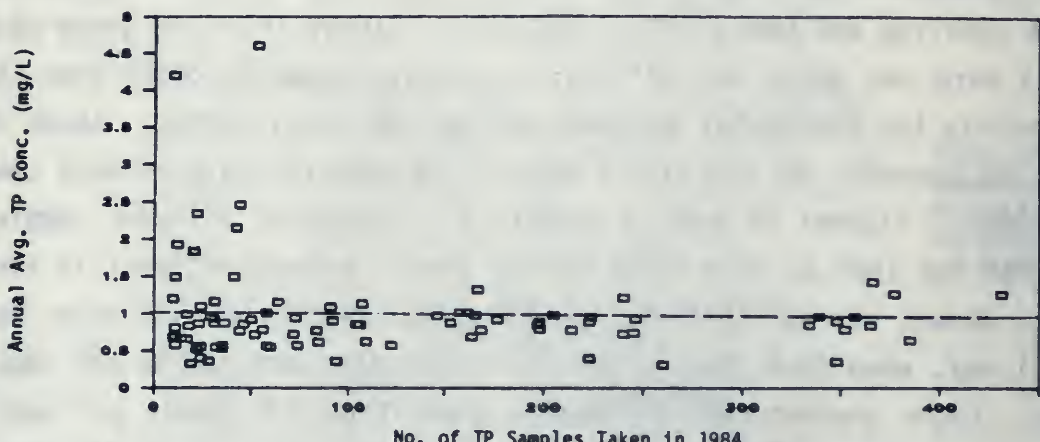

FIGURE 16 - SAMPLING FREQUENCY VS. 1984 ANNUAL AVERAGE EFFLUENT TP CONCENTRATION FOR 96 PLANTS IN ONTARIO

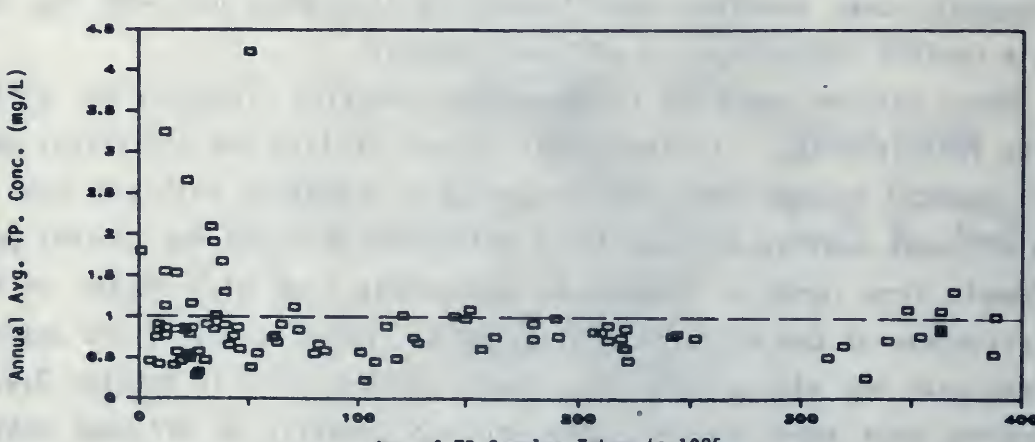

FIGURE 17 - SAMPLING FREQUENCY VS. 1985 ANNUAL AVERAGE EFFLUENT TP CONCENTRATION FOR 96 PLANTS IN ONTARIO

3.4.2 Analytical Procedures

Approximately three-quarters of the WPCPs contacted during the course of this investigation conducted some routine analysis of effluent samples for phosphorus, either on-site or at a central municipal or MOE laboratory other than the analyses required for compliance assessment. The analytical methodologies used varied considerably. Some laboratories used approved Standard Methods[5], while others used rapid 'packaged' analytical procedures. In some instances, the analytical procedures did not incorporate a digestion step and thus did not measure total phosphorus. Few laboratories measured total and soluble phosphorus.

The Phase 3 investigations at the Collingwood WPCP showed that plant analytical results were erratic and that they significantly overestimated the final effluent total phosphorus concentration[3]. These plant results were meaningless for chemical dosage control.

All laboratories should have a detailed quality assurance/quality control plan in place and in practice so that the analytical results are continuously evaluated for accuracy. Further, the analytical procedures should include both total and soluble fractions of the effluent phosphorus concentration as chemical dosage control is impossible without this information.

3.4.3 Dosage Calculations

The Phase 1 plant surveys and the field evaluations indicated that many plants are not accurately calculating chemical dosages. The investigations at the Collingwood WPCP were illustrative of the problem[3]. In this case, dosages had been over-estimated by up to twenty-five percent because of an error in calibration of one of the alum storage tanks. Many plants do not record daily chemical usage rates and few plants verify tank volume measurements by measuring chemical metering pump delivery rates. Plants with multiple dosage points seldom measure the chemical feed rate at each point so that the actual dosage to east and west components of a total facility, for example, can be defined. Metal content of iron solutions (ferric and ferrous) vary significantly and few plants actually analyze the chemicals being used for phosphorus removal.

3.4.4 Plant Bypass

Design and operation of bypass facilities at WPCPs varies considerably and can impact directly on the reported performance of a WPCP. Plant surveys identified that the following bypass modes were included among the approximately 100 WPCPs contacted during Phase 1:

- bypassing was limited to the collection system upstream of the plant under high flow conditions (CSO and/or pumping station bypasses) and no bypassing was provided at the WPCP;
- bypassing occurred at the influent wet well or headworks only;
- bypassing occurred after primary clarification only; and
- bypassing occurred at either the headworks and/or after the primary clarifiers.

In WPCPs which did provide for bypassing at the plant, about half bypassed to the plant outfall and did not include any bypass flow in the plant final effluent sample. The other half of these WPCPs bypassed to the chlorine contactor and the bypass flow was included in the final effluent sample if bypassing was occurring during the time that final effluent was sampled. In some facilities, the bypass flow would be included in the final effluent sample but plant staff intentionally did not sample when bypassing was occurring at the plant.

It was noted during conversation with plant staff that many operating authorities resist bypassing even if mechanical facility is provided within the plant to allow bypassing. In these situations, the secondary component of the facility can be subject to long-term upset due to washout under extreme flow conditions which could be avoided if upstream bypassing was practised. Long-term effluent quality deterioration can result from an attempt to avoid a short-term effluent excursion related to bypassing.

WPCP bypassing is a contentious issue and it is not within the scope of this investigation to develop a management strategy to handle plant bypasses. It is apparent, however, that the inclusion or exclusion of bypass flows in effluent samples used to measure compliance status is not consistent in these facilities and further evaluation is necessary to address this issue.

3.4.5 Cost Factors

Unlike many fixed operating costs such as labour and energy, chemical costs at a WPCP can be reduced simply by reducing chemical dosage. Thus, during periods of fiscal restraint, an operating authority can exercise some control over the escalating operating costs associated with sewage treatment by reducing the usage rate of chemicals associated with phosphorus removal. As chemical dosage is optimized so that the facility operates nearer the effluent guideline level, improved dosage control is necessary to ensure that compliance is maintained. In addition, short-term excursions due to plant upset are more likely because there is a smaller margin of error. These short-term excursions became more significant as the time frame for compliance assessment becomes shorter (i.e. monthly versus yearly averages).

These investigations showed that the market for phosphorus removal chemicals, particularly iron salts, is very dynamic and there can be significant changes in chemical costs from year to year. Duffin Creek WPCP was able to significantly improve phosphorus removal efficiency and, at the same time, reduce chemical costs considerably by changing from alum to ferrous sulphate. WPCP operating authorities should routinely reassess the market for phosphorus removal chemicals as an alternative to reducing costs through reducing chemical usage.

3.4.6 WPCP Maintenance Program

Routine maintenance of secondary clarifiers typically involves taking each clarifier out-of-service approximately every five to seven years for inspection and refurbishing of drives, chains and other mechanical components. In WPCPs with a large number of secondary clarifiers, the increased hydraulic load resulting when a clarifier is out-of-service can be redistributed over the remaining clarifiers without severely impacting on effluent quality. In facilities with fewer clarifiers, the impact of redistributing the hydraulic load may be more severe. When compliance is measured on an annual basis, poorer quality effluent produced during maintenance periods can often be compensated for by improved operation over the longer term. However, assessment of compliance on a shorter-term basis (i.e. monthly) will create problems during periods of maintenance. Redundancy of unit processes and equipment needs to be reconsidered in light of the changing compliance assessment approach.

3.5 Summary of Findings

The three most common causes of inadequate phosphorus removal performance at wastewater treatment facilities in the Great Lakes Basin were:

(i) Inadequate chemical dosage

(ii) Excessive hydraulic loading on secondary clarifiers

(iii) Inadequate sludge management practices which lead to excessive suspended solids losses to the final effluent

The investigations showed that phosphorus removal inadequacies associated with chemical dosage can be readily rectified. Increased chemical dosage can often compensate for phosphorus removal problems associated with hydraulic loading and sludge management problems depending on the severity and duration of these problems, and particularly when a long-term (annual) compliance assessment approach is used. Monitoring of compliance on a shorter-term basis (monthly) will reduce the ability of a WPCP to compensate for hydraulic and sludge management problems by increasing chemical dosage. The shorter-term compliance assessment approach necessitates increased performance monitoring and increased diligence to chemical dosage control so that short term effluent quality excursions due to plant upsets can be quickly identified and corrected by compensating periods of improved effluent quality.

4.0 PHOSPHORUS LOADING MANAGEMENT STRATEGIES

4.1 General

In order to achieve the phosphorus loading reductions proposed for the Lake Ontario drainage basin and the Lake Erie drainage basin, a number of alternative management strategies could be considered including:

i) Improvements at plants which are not presently complying with the 1.0 mg/L annual objective, to ensure consistent compliance

ii) Modification to the existing method of assessing compliance, from an "annual average" to "monthly average" total phosphorus limit

iii) Selective improvements at some or all plants to achieve (or maintain, if already achieving) higher levels of phosphorus removal than presently required by the MOE

The impact of these management strategies was assessed by evaluation of the loading reduction which each would have achieved in each receiving basin in 1984 and 1985. The projected basin loadings for the time period 1986 to 1990 were estimated based on maintaining present WPCP performance and the comparative loadings calculated for each alternative phosphorus management approach. The additional costs of implementing each phosphorus removal management strategy were estimated.

4.2 Projected Basin Loadings

Based on the historical data, flow and phosphorus loadings were projected for the period 1986 to 1990 for all basins (Lake Erie, Lake Ontario/St. Lawrence River, Lake Huron and Lake Superior). Flow projections were based on a linear regression of flow data for each basin for the time period 1981 to 1985. Basin phosphorus loadings for 1986 to 1990 were projected based on the extrapolated flow and the 1985 aggregate average effluent TP concentration for each basin. This calculation approach assumes that 1985 effluent quality in each basin can be maintained despite the anticipated increase in flow through WPCPs in the basins. All basins showed a decline in aggregate average TP concentration over the period 1981 to 1985 despite in-

creases in total flow during this period. However, as the flow through WPCPs approaches the design capacity, these facilities will have greater difficulty in maintaining 1985 effluent quality. To provide an indication of the possible impact of flow increases on effluent quality over the projection period, projected basin loads were compared to existing WPCP design capacity serving each basin.

4.2.1 Lake Erie Basin

Actual and projected flows from treatment plants under consideration in the Lake Erie Basin are presented in Figure 18. Based on the linear regression, the flow to Lake Erie from these plants has increased at an average rate of 2.5 percent per year for the period from 1981 to 1985. In 1985, 18.0 percent of the total basin flows were from four plants which had exceeded design capacity. This is predicted to increase to 39.9 percent in 1990, as eleven plants exceed their design capacity. The total basin WPCP design flow capacity will be exceeded in 1991 if no expansions occur in the meantime.

The total phosphorus loading over the period from 1981 to 1985 has averaged 242.8 tonnes per year, with no apparent trend as indicated in Figure 19. The annual loading increase projected based on 1985 effluent quality and a 2.5 percent per year flow increase is also shown in Figure 19.

4.2.2 Lake Ontario/St. Lawrence River Basin

Total flows from municipal treatment plants in the Lake Ontario/ St. Lawrence River Basin have increased at a rate of approximately 1.7 percent per year over the period from 1981 to 1985, as shown in Figure 20 and are projected to exceed basin design flow capacity in 1997. In 1985, 12.4 percent of the total basin flows were from 8 plants that had exceeded design capacity. If no plant expansions occur, this would increase to 28 percent of flows, from 11 plants in the basin by 1990.

As illustrated in Figure 21, phosphorus loadings to the Lake Ontario/St. Lawrence River Basin have declined over the period 1981 to 1985 despite increases in flow. Extrapolation of loading data based on 1985 effluent quality suggests that phosphorus loadings will increase to approximately 1000 tonnes/year by 1988.

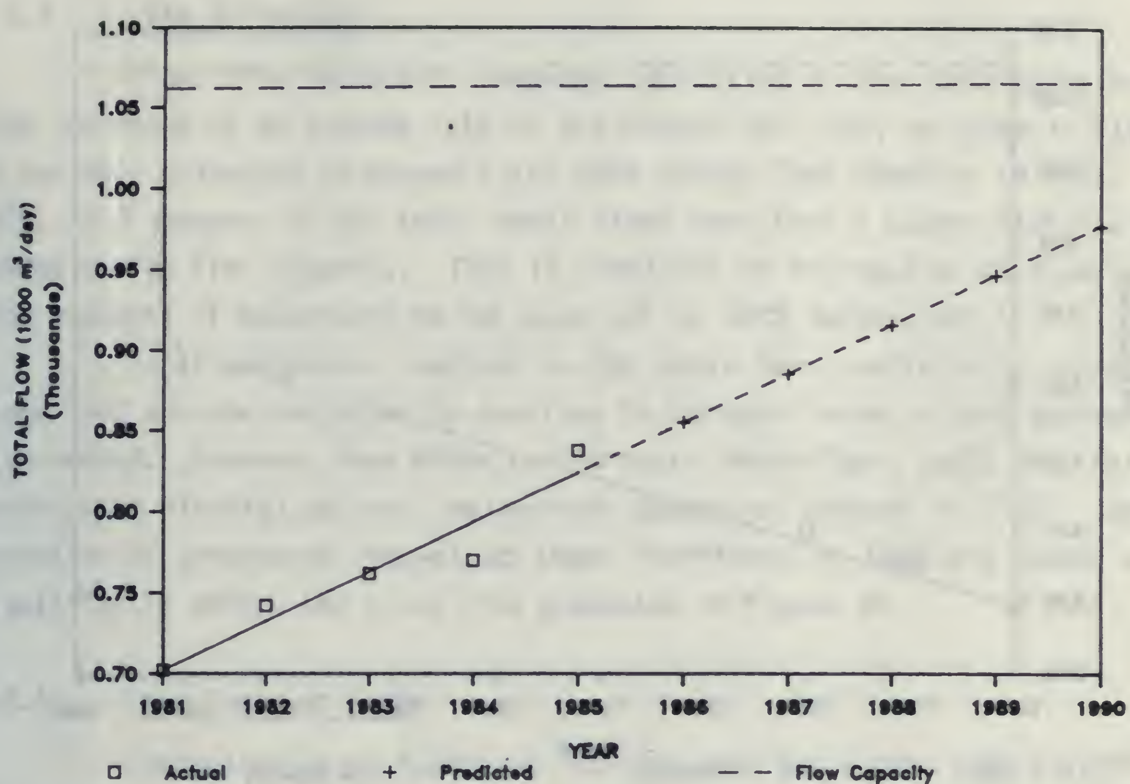

FIGURE 18 - LAKE ERIE DRAINAGE BASIN - TOTAL FLOW VS. TIME

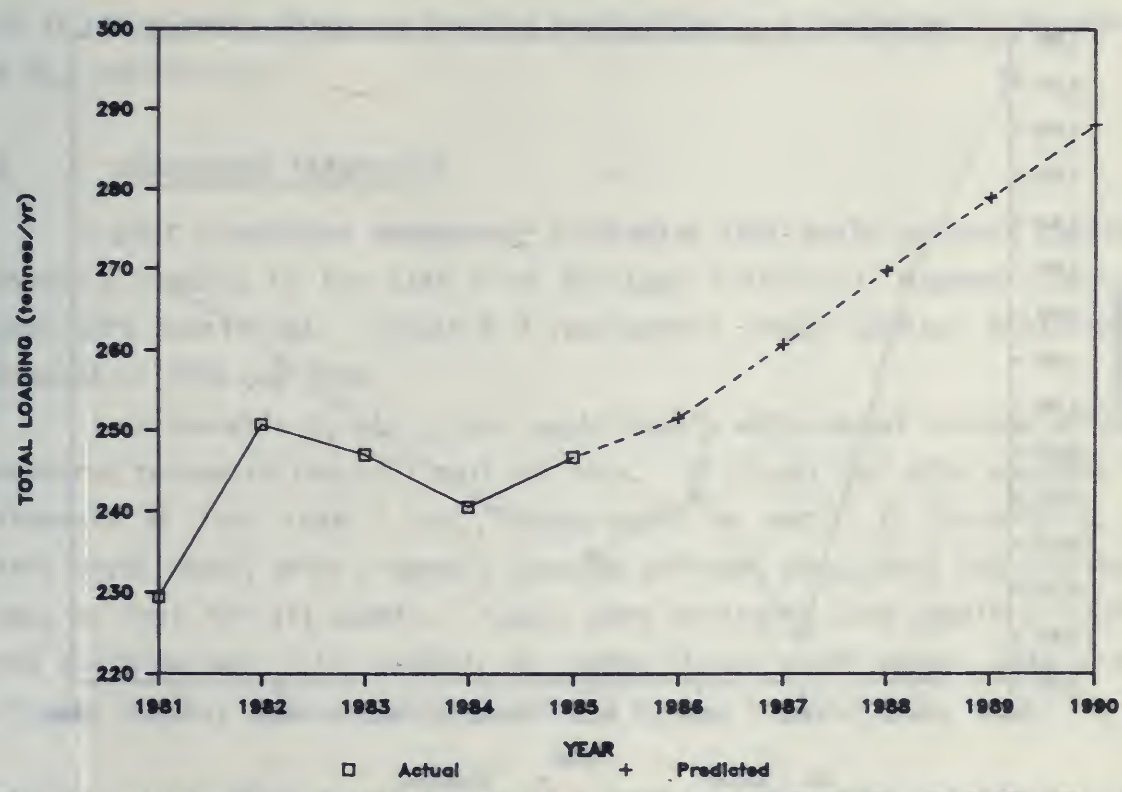

FIGURE 19 - LAKE ERIE DRAINAGE BASIN - TOTAL PHOSPHORUS LOADING VS. TIME

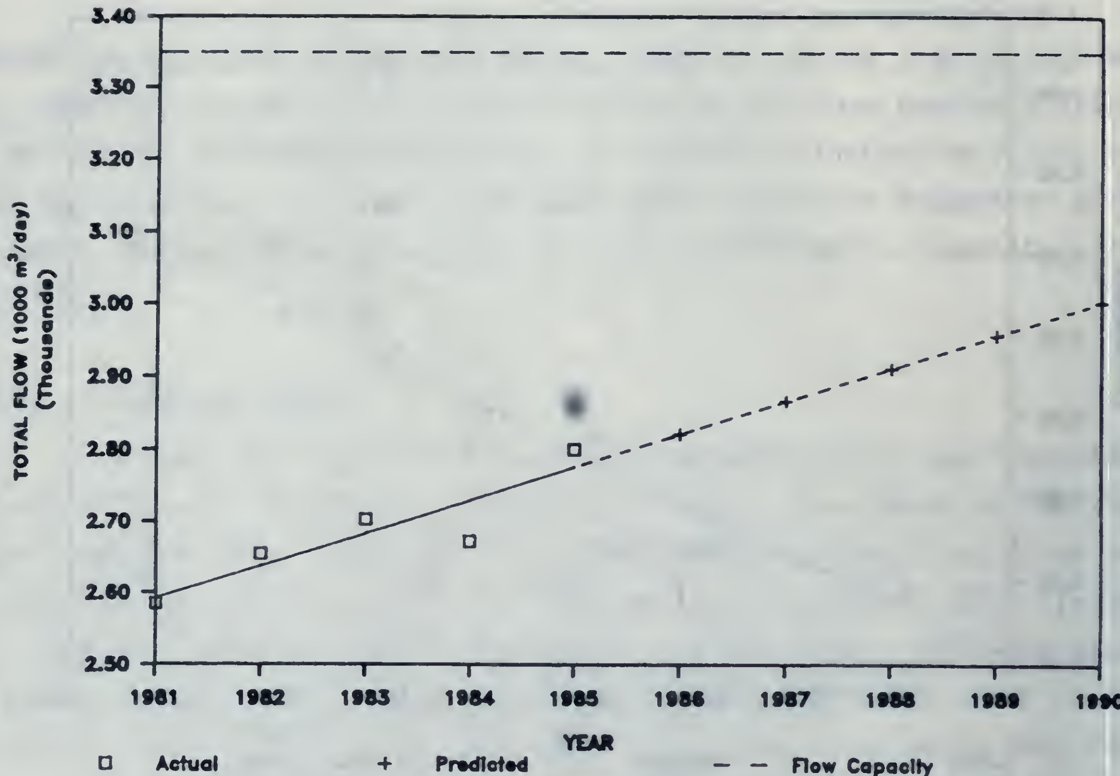

FIGURE 20 - LAKE ONTARIO DRAINAGE BASIN - TOTAL FLOW VS. TIME

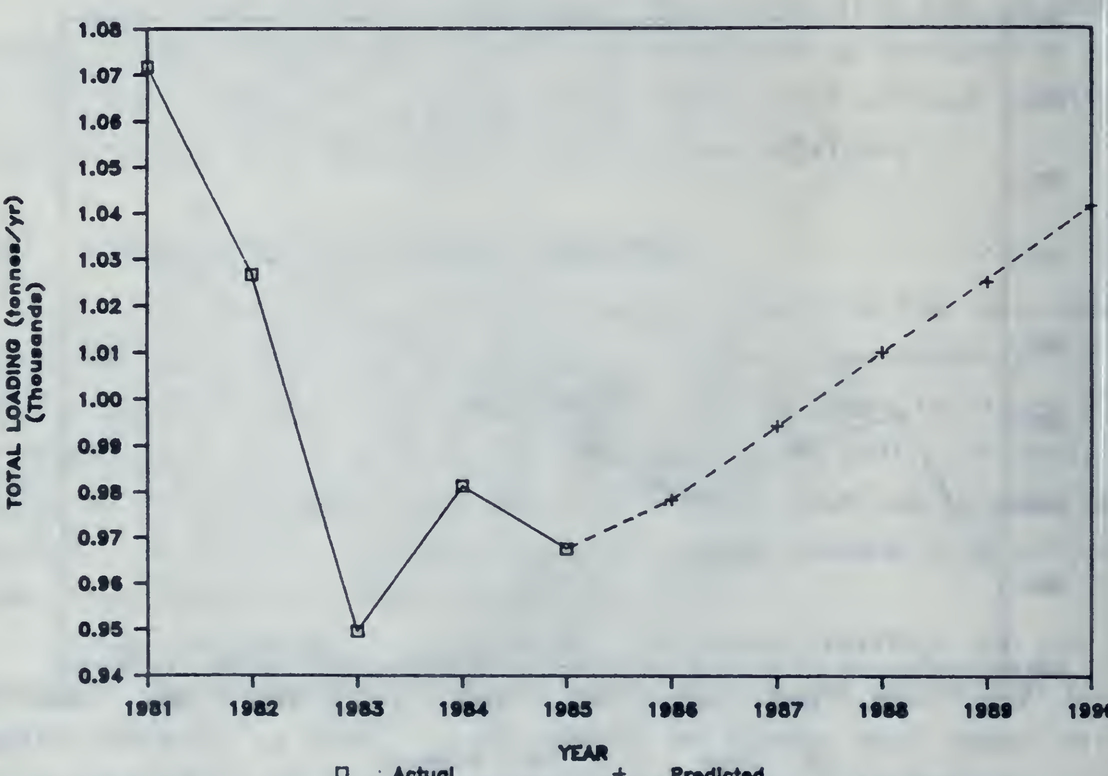

FIGURE 21 - LAKE ONTARIO DRAINAGE BASIN - TOTAL PHOSPHORUS LOADING VS. TIME

4.2.3 Lake Huron Basin

Flows from municipal treatment facilities in the Lake Huron Basin have increased at an average rate of 3.2 percent per year, as shown in Figure 22 and were projected to exceed total WPCP design flow capacity in 1987. In 1985, 23.3 percent of the total basin flows were from 4 plants that had exceeded design flow capacity. This is predicted to increase to 64.0 percent, from 9 plants if expansions do not occur at any WPCP before 1990.

Total phosphorus loadings to the basin have continuously increased since 1982 and are projected to continue to increase based on this extrapolation method. However, four WPCPs in the basin (Port Elgin, Sault Ste. Marie, Sudbury and Mikkola) had not implemented phosphorus removal in 1985. Implementation of phosphorus removal at these facilities in 1986 and beyond will significantly affect the trend line projected in Figure 23.

4.2.4 Lake Superior Basin

Extrapolation of flows and loadings over the period 1986 to 1990 in the Lake Superior basin is of questionable value since only one facility (Thunder Bay WPCP) is included in the data base. Despite the known limitation in these data, flow and loading projections are presented in Figures 24 and 25, respectively.

4.3 Management Strategies

Four phosphorus management strategies that would decrease the total phosphorus loading to the Lake Erie and Lake Ontario/St. Lawrence drainage basins were considered. Scenario 0 represented those loadings actually experienced in 1984 and 1985.

In Scenario 1, all plants would comply with annual average effluent phosphorus concentration of 1 mg/L or less. If plants had site specific requirements of less than 1 mg/L, these would be met. In Scenario 2, all plants would comply with a monthly average effluent phosphorus requirement of 1 mg/L or less for all months. Again, more stringent site specific requirements would be met. In Scenario 3, large plants would comply with a more stringent monthly effluent requirement of 0.9 mg TP/L or less, while the re-

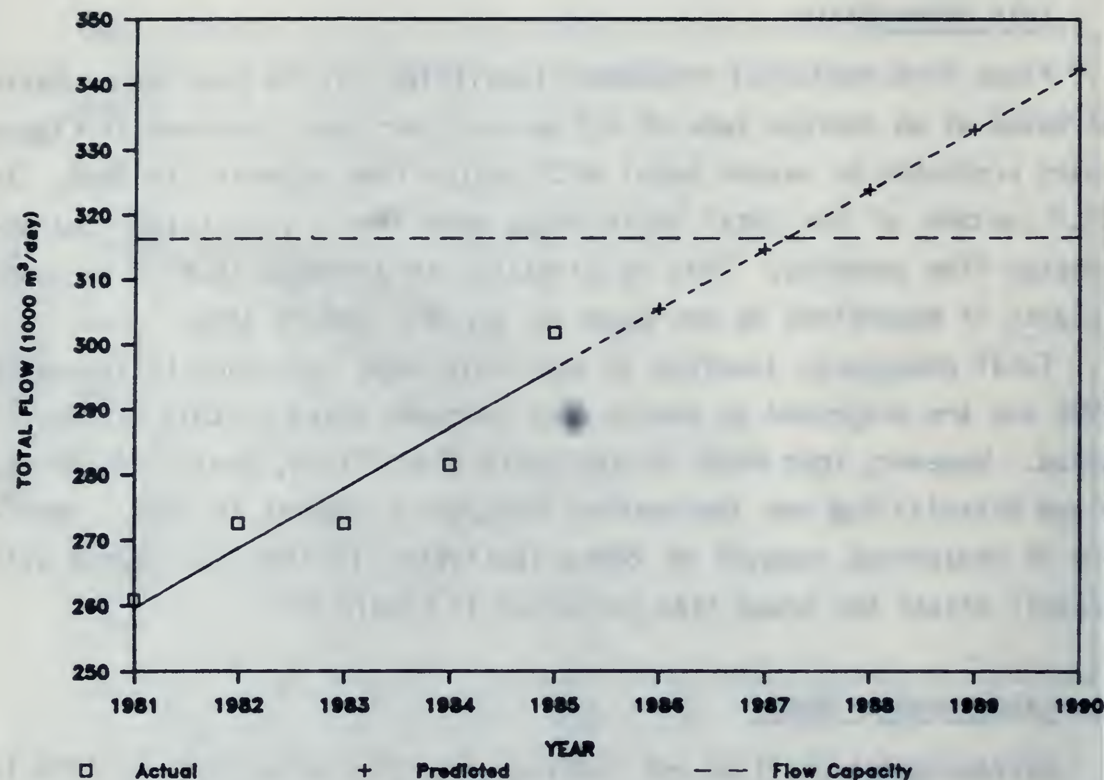

FIGURE 22 - LAKE HURON DRAINAGE BASIN - TOTAL FLOW VS. TIME

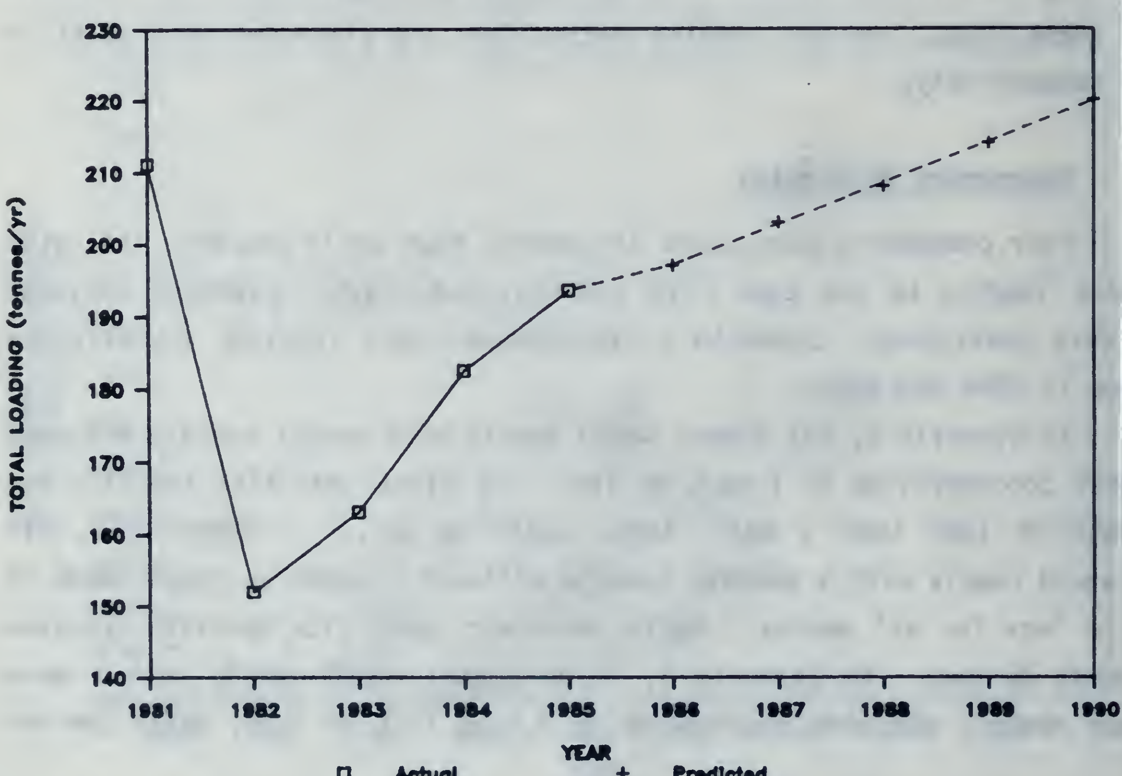

FIGURE 23 - LAKE HURON DRAINAGE BASIN - TOTAL PHOSPHORUS LOADING VS. TIME

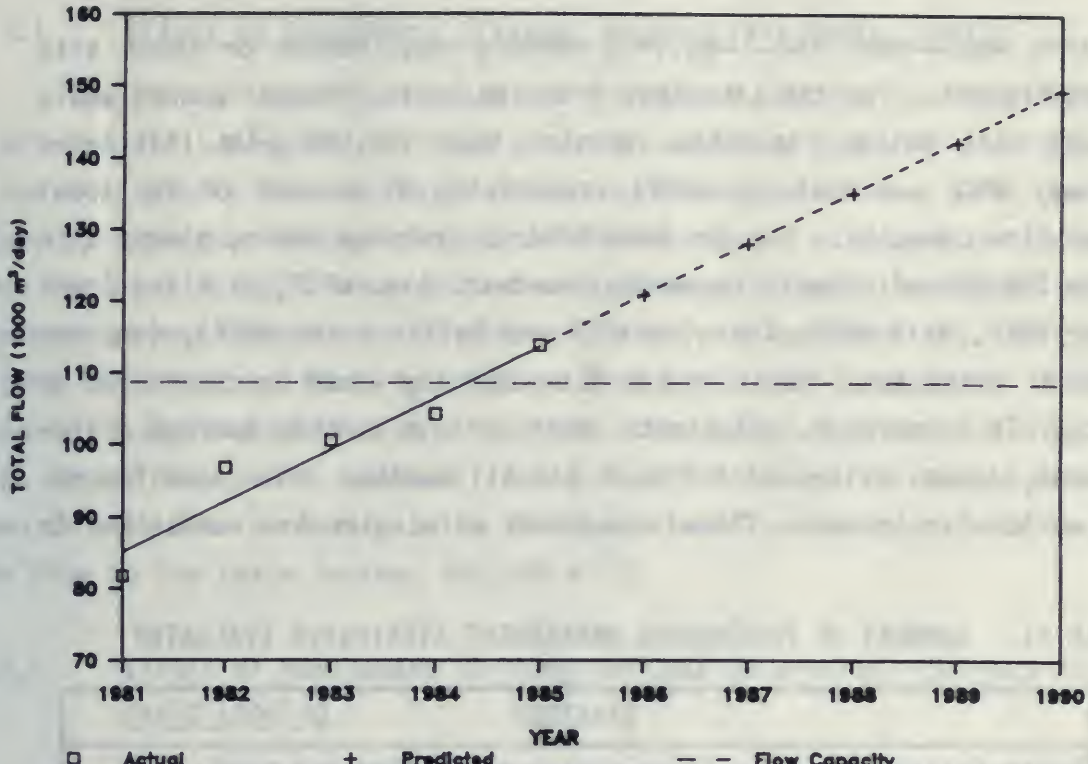

FIGURE 24 - LAKE SUPERIOR DRAINAGE BASIN - TOTAL FLOW VS. TIME

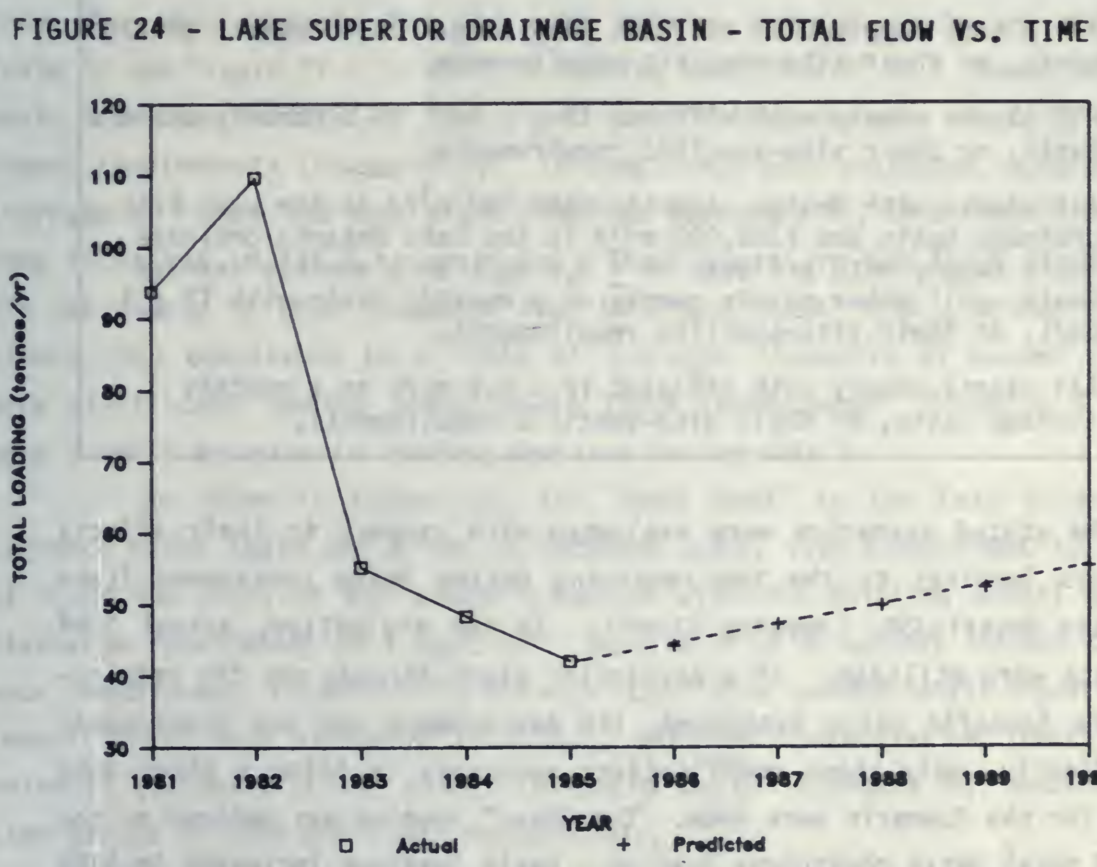

FIGURE 25 - LAKE SUPERIOR DRAINAGE BASIN - TOTAL PHOSPHORUS LOADING VS. TIME

maining plants would meet the 1 mg TP/L monthly requirement or their site specific requirement. For the Lake Erie Drainage basin, "large" plants would include those with design capacities greater than 100,000 m^3/d (Kitchener WPCP, Greenway WPCP and Westerly WPCP), comprising 39 percent of the total basin design flow capacity. For the Lake Ontario drainage basin, plants with greater than 200,000 m^3/d design capacity (Woodward Ave. WPCP, Highland Creek WPCP, Humber WPCP, Main WPCP, Lakeview WPCP and Duffin Creek WPCP), comprising 68 percent of the total basin design flow capacity would be considered as large plants. In Scenario 4, all plants would achieve monthly average effluent phosphorus concentrations of 0.9 mg/L for all months. Site specific requirements would also be met. These management strategies are summarized in Table 41.

TABLE 41. SUMMARY OF PHOSPHORUS MANAGEMENT STRATEGIES EVALUATED

SCENARIO	STRATEGY
0	Basin loadings as actually experienced in 1984 and 1985.
1	All plants comply with effluent TP $\leq$ 1 mg/L on an annual average basis, or their site-specific requirements.
2	All plants comply with effluent TP $\leq$ 1 mg/L on a monthly average basis, or their site-specific requirements.
3	All plants with design capacity >100,000 m^3/d in the Lake Erie drainage basin and >200,000 m^3/d in the Lake Ontario drainage basin comply with effluent TP $\leq$ 0.9 mg/L on a monthly average basis. All other plants comply on a monthly basis with TP $\leq$ 1 mg/L, or their site-specific requirements.
4	All plants comply with effluent TP $\leq$ 0.9 mg/L on a monthly average basis, or their site-specific requirements.

The stated scenarios were evaluated with respect to their effects on phosphorus loadings to the two receiving basins being considered (Lake Erie and Lake Ontario/St. Lawrence River). In the evaluation, actual 1984 and 1985 data were utilized. If a particular plant already met the requirements of the Scenario being evaluated, its performance was not downgraded. More specifically, only those modifications necessary to bring a plant into compliance for the Scenario were made. The "base" loading was defined as the actual 1983 total basin phosphorus loading. Basin loadings increased in 1986 to 1990 in proportion to the projected increases in basin flows. Details of the calculation methodology used were presented in the Phase 1 report(1).

4.3.1 Effect of Management Strategy on Lake Erie Basin Loading

The actual, hypothetical and projected loadings and loading reductions for the Lake Erie Drainage basin are shown in Table 42 and Figure 26. Since most plants in this basin have consistently performed well, as indicated by aggregate average phosphorus concentrations of less than the compliance limit of 1 mg/L, none of the management strategies evaluated produced phosphorus load reductions of more than about 20 percent. As indicated in Figure 26, the "base load" to the Lake Erie Basin will be exceeded in 1986 if Scenario 1 was implemented as a phosphorus management approach strategy. The most severe management approach (Scenario 4) maintains the total phosphorus load to Lake Erie at levels below the "base load" until almost 1989, or until the flow to the basin reaches 950,000 m^3/d.

4.3.2 Effect of Management Strategy on Lake Ontario/St. Lawrence River Basin Loading

The actual, hypothetical and projected loadings and loading reductions for each scenario for the Lake Ontario drainage basin are shown in Table 43 and Figure 27. In 1985, a loading reduction of 87.6 tonnes per year would have been realized if each plant had complied with the existing MOE effluent requirements (Scenario 1). If compliance were evaluated using monthly averages of 1 mg/L and each plant complied (Scenario 2), this reduction would have increased to 134.2 tonnes/year. Since there are two large plants that did not comply in 1985 (Woodward Ave. WPCP and Humber WPCP), bringing these plants into compliance to a limit of 0.9 mg/L (Scenario 3) caused an even more significant loading reduction to 160.4 tonnes/year. Scenario 4 caused only a small decrease in loading compared to Scenario 3.

As shown in Figure 27, the "base load" to the Lake Ontario/St. Lawrence River Basin would not be exceeded until 1990 (equivalent to a flow of 3,004,000 m^3/d) if all plants complied with the existing annual average discharge requirement of 1 mg/L TP. Imposition of a monthly average compliance requirement (Scenario 2) extends this time period until about 1995. Imposition of more stringent (0.9 mg/L) effluent concentration limits, on a selected (Scenario 3) or across-the-board basis (Scenario 4), extends the time period to 1998 and 1999, respectively.

TABLE 42. COMPARISON OF PHOSPHORUS MANAGEMENT STRATEGIES - EFFECT OF TP LOADING REDUCTION TO LAKE ERIE DRAINAGE BASIN

		HYPOTHETICAL TP LOADINGS (tonnes/yr) (BASED ON ACTUAL FLOW & TP DATA)			PROJECTED TP LOADINGS (Based on Projected Flows and 1985 Aggregate Average Effluent TP Concentration)				
	DESCRIPTION	1983	1984	1985	1986	1987	1988	1989	1990
FLOWS ($10^3 m^3/d$)	Actual and projected flows based on linear regression of 1981-1985 basin flows.	762.0	770.0	837.5	856.8	887.8	918.9	949.9	980.9
SCENARIO 0	Loadings based on 1984 and 1985 data, and projected flows.	246.9	240.5 (6.4)	246.7 (-0.2)	251.6 (-4.7)	260.7 (-13.8)	269.8 (-22.9)	278.9 (-32.0)	288.1 (-41.2)
SCENARIO 1	All plants comply annually with average effluent TP $\leq$ 1 mg/L or site-specific requirements.		225.9 (20.0)	237.8 (9.1)	242.1 (4.8)	250.9 (4.0)	259.7 (-12.8)	268.4 (-21.5)	277.2 (-30.3)
SCENARIO 2	All plants comply monthly with average effluent TP $\leq$ 1 mg/L or site-specific requirements.		215.2 (31.7)	226.0 (20.9)	230.2 (16.7)	238.5 (8.4)	246.9 (0.0)	255.2 (-8.3)	263.5 (-16.6)
SCENARIO 3	Plants with >100,000 m^3/d capacity comply with 0.9 mg/L, all others comply with 1 mg/L or site-specific requirements - monthly basis		213.0 (33.9)	223.7 (23.2)	227.8 (19.1)	236.0 (10.9)	244.3 (2.6)	252.5 (-5.6)	260.8 (-13.9)
SCENARIO 4	All plants comply monthly with average effluent TP $\leq$ 0.9 mg/L or site-specific requirements.		209.2 (37.7)	219.8 (27.1)	223.9 (22.0)	231.0 (14.9)	240.1 (6.8)	248.2 (-1.3)	256.3 (-9.4)

(   ) = Loading Reduction from 1983 Load (tonnes/yr)

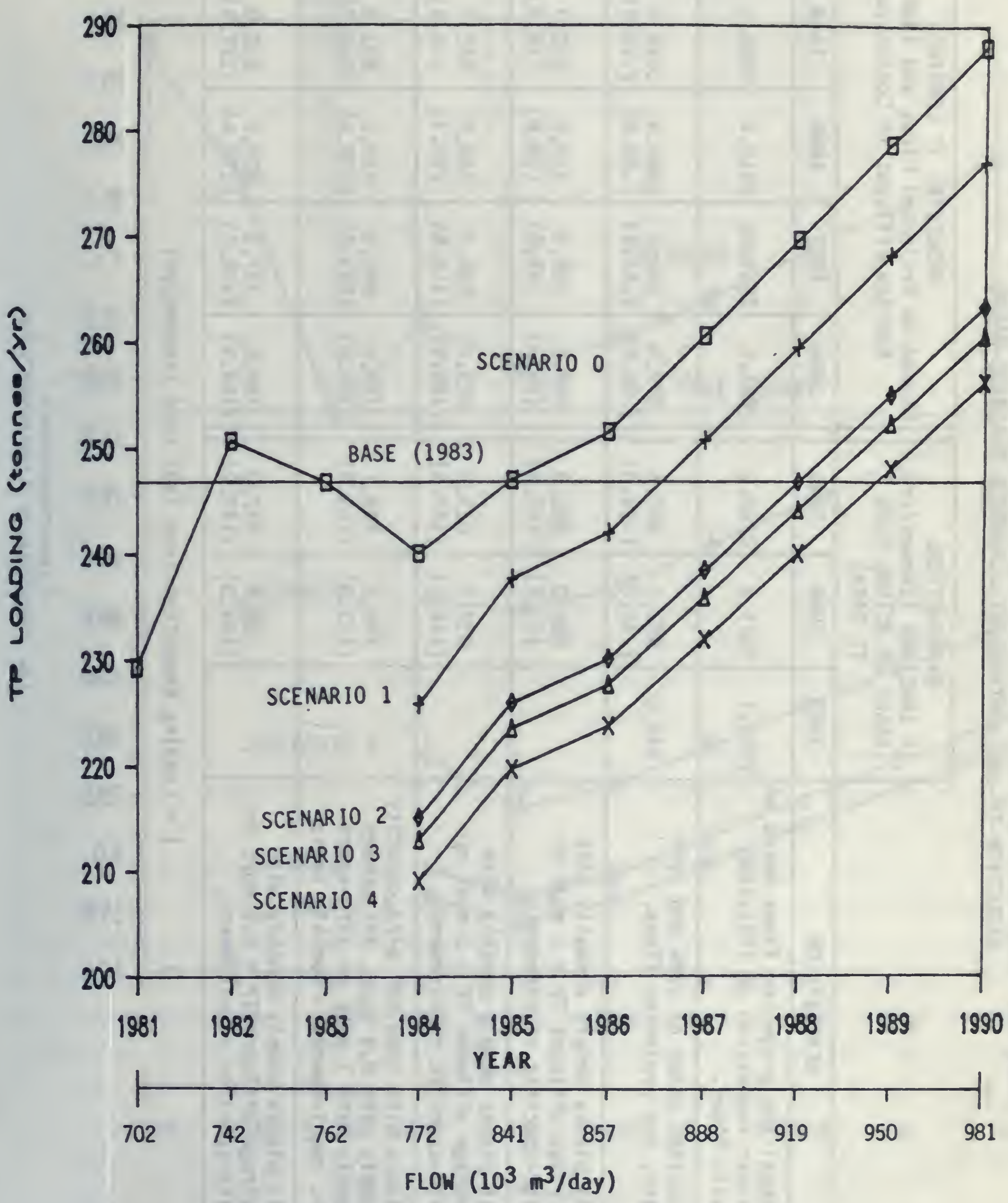

FIGURE 26 - EFFECT OF PHOSPHORUS MANAGEMENT STRATEGIES ON PHOSPHORUS LOADINGS ON THE LAKE ERIE DRAINAGE BASIN

TABLE 43. COMPARISON OF PHOSPHORUS MANAGEMENT STRATEGIES - EFFECT OF TP LOADING REDUCTION TO LAKE ONTARIO/ST. LAWRENCE DRAINAGE BASIN

		HYPOTHETICAL TP LOADINGS (tonnes/yr) (BASED ON ACTUAL FLOW & TP DATA)			PROJECTED TP LOADINGS (Based on Projected Flows and 1985 Aggregate Average Effluent TP Concentration)				
	DESCRIPTION	1983	1984	1985	1986	1987	1988	1989	1990
FLOWS ($10^3 m^3/d$)	Actual and projected flows based on linear regression of 1981-1985 basin flows.	2702.7	2671.5	2798.9	2821.4	2867.08	2912.6	2956.1	3003.7
SCENARIO 0	Loadings based on 1984 and 1985 data, and projected flows.	949.5	981.3 (-31.8)	967.5 (-18.0)	978.3 (-28.8)	994.1 (-44.6)	1009.9 (-60.4)	1025.0 (-75.5)	1041.5 (-92.0)
SCENARIO 1	All plants comply annually with average effluent TP ≤ 1 mg/L or site-specific requirements.		886.0 (63.5)	881.9 (67.6)	890.2 (59.3)	904.5 (45.0)	918.9 (30.6)	932.7 (16.8)	947.7 (1.8)
SCENARIO 2	All plants comply monthly with average effluent TP ≤ 1 mg/L or site-specific requirements.		832.9 (116.6)	815.9 (133.6)	823.6 (125.9)	836.9 (112.6)	850.2 (99.3)	862.9 (86.6)	876.8 (72.7)
SCENARIO 3	Plants with >200,000 m^3/d capacity comply with 0.9 mg/L, all others comply with 1 mg/L or site-specific requirements - monthly basis		795.7 (153.8)	786.1 (163.4)	793.5 (156.0)	806.3 (143.2)	819.1 (130.4)	831.3 (118.2)	844.7 (104.8)
SCENARIO 4	All plants comply monthly with average effluent TP ≤ 0.9 mg/L or site-specific requirements.		785.5 (164.0)	777.3 (172.2)	784.6 (164.9)	797.3 (152.2)	809.9 (139.6)	822.0 (127.5)	835.3 (114.2)

(   ) = Loading Reduction from 1983 Load (tonnes/yr)

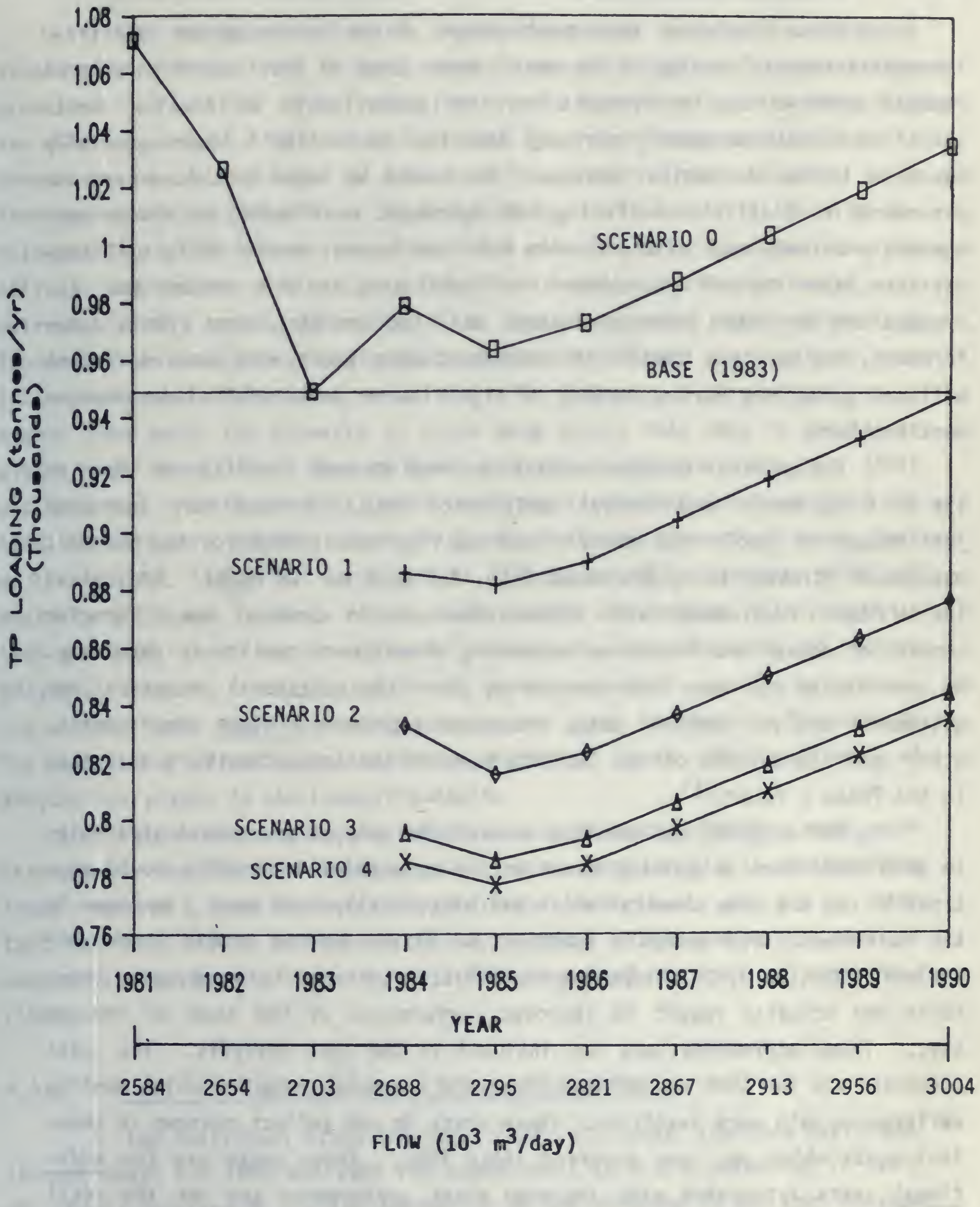

FIGURE 27 - EFFECT OF MANAGEMENT STRATEGIES ON PHOSPHORUS LOADINGS TO THE LAKE ONTARIO DRAINAGE BASIN

4.4 Costs of Implementation

Since the plant assessment phases of the investigation identified inadequate chemical dosage as the most common cause of inefficient phosphorus removal performance, improvements to plant operation to achieve the limits specified by each management strategy described in Section 4.3 were generally based on increased chemical dosages. It should be noted that long-term improvements to facilities suffering from hydraulic overloading or sludge management problems, such as the Toronto Main and Toronto Humber WPCP, will necessitate major capital expenditures not considered in this evaluation. Increased and optimized chemical dosages will improve phosphorus removal performance, but may not result in consistent compliance with more stringent effluent guidelines during periods of high flow or periods of sludge management problems.

The chemical dosage increase required at each facility was based on the existing dosage and removal performance data. Dosages were increased just enough to comply with the effluent quality requirement for the specific management strategy being evaluated (i.e. 0.9 mg/L or 1.0 mg/L). To achieve the effluent requirement with minimum increase in chemical usage, precise control of dosage and intensive monitoring of effluent quality is necessary. No cost factor has been incorporated to cover the additional analytical requirements and the chemical usage increases represent minimum requirements. Other specific details of the facility remediation approaches were described in the Phase 1 report(1).

The costs of implementing each of the phosphorus removal strategies in each basin were calculated based on the assumption that WPCPs would continue to use the same chemical which had historically been used. As shown in the Collingwood WPCP analysis (Section 3.3.2) and in the Duffin Creek WPCP analysis (Section 3.3.3), imposing sewer discharge controls or changing chemicals may actually result in improved performance at the same or reduced cost. These approaches were not included in the cost analysis. The costs presented are for 1984 and 1985 as these are the only years for which monthly performance data were available. These costs do not reflect changes in chemical costs which may have occurred since 1985. These costs are the additional costs associated with improved plant performance and not the total costs of phosphorus removal. Other details and assumptions associated with the development of these costs were presented in the Phase 1 report(1).

4.4.1 Lake Erie Drainage Basin

The additional costs of implementing each phosphorus management strategy in 1984 and 1985 at each plant in the Lake Erie drainage basin are presented in Table 44. Total additional costs for all plants in the basin are also presented. Total costs increase in proportion to the increase in phosphorus removal achieved by each scenario. However, annual costs range from approximately $20,000 to implement Scenario 1, which essentially involves bringing all plants into compliance with the existing annual average effluent requirement of 1 mg/L, to $50,000 to impose a basin-wide monthly requirement of 0.9 mg/L. Almost half the costs associated with implementing Scenario 1 are incurred at one primary plant (Amherstburg) where polymer addition would need to be practised. Costs for Scenario 2 were significantly higher than costs for Scenario 1, since many plants that were in compliance with 1 mg/L on an annual average basis had some months in which this limit was exceeded. Estimated total additional costs required for Scenario 2 for 1984 and 1985 were $80,000. Scenario 3 was similar to Scenario 2 except that a 0.9 mg TP/L limit for large plants (Kitchener WPCP, Greenway WPCP and Westerly WPCP) was imposed. Since these plants did perform fairly well in 1984 and 1985, there was a very small increase in costs for 1984 and 1985 to $83,000. Scenario 4 imposed a 0.9 mg/L phosphorus limit on all plants causing a relatively small cost increase at each plant compared to Scenario 2. The cumulative effect resulted in an estimated total additional cost of $95,000 for plants in the Lake Erie Basin.

Figure 28 compares the relative costs of each phosphorus management strategy to the costs of bringing plants into compliance with the existing annual average 1 mg/L TP concentration limit (Scenario 1). It can be noted that the total costs increase with the severity of the phosphorus requirements, to a maximum for Scenario 4 at 210 percent of the cost of Scenario 1 (1985).

4.4.2 Lake Ontario/St. Lawrence River Drainage Basin

The individual plant and total Lake Ontario/St. Lawrence basin additional costs for 1984 and 1985 for Scenarios 1 to 4 are presented in Table 45. Costs incurred by the implementation of any strategy in the Lake Ontario Basin are significantly higher than costs for the same management strategy in

TABLE 44. COSTS OF PHOSPHORUS MANAGEMENT STRATEGIES IN THE LAKE ERIE DRAINAGE BASIN

PLANT	SCENARIO 1		SCENARIO 2		SCENARIO 3		SCENARIO 4	
	1984	1985	1984	1985	1984	1985	1984	1985
Amherstburg WPCP	13,614	10,784	13,800	13,480	13,800	13,480	13,956	13,765
Brantford WPCP				50		50	12	150
Galt WPCP (Cambridge)			60		60		284	58
Hespeler WPCP (Cambridge)		1,450	625	1,937	625	1,937	861	2,222
Preston WPCP (Cambridge)				200		200		284
Chatham WPCP		40		260		260	58	355
Dresden WPCP			336		336		432	19
Dunnville WPCP	20		344		344		367	
Fergus WPCP								
Guelph WPCP	6,670	7,137	8,174	8,083	8,174	8,803	8,380	8,846
Ingersoll New WPCP			102	294	102	294	131	354
Kitchener WPCP						177		177
Leamington WPCP			116	611	116	611	236	641
Adelaide WPCP (London)			121		121		470	134
Greenway WPCP (London)			1,271	746	1,907	1,119	1,907	1,119
Oxford WPCP (London)			156		156		259	48
Pottersburg WPCP (London)				186		186	166	372
Vauxhall WPCP (London)			177	80	177	80	300	160
Belle River - Maidstore WPCP			355	346	355	346	503	484
Corunna P.V. Plant (Moore)			237	622	237	622	362	770
Paris WPCP				31		31		55
Sarnia WPCP				1,738		1,738	1,923	5,213
Simcoe WPCP			154		154			195
St. Thomas WPCP	5,199	2,904	4,976	5,532	4,976	5,532	6,258	4,978
Stratford WPCP	1,070		2,455		2,455		2,641	
Tillsonburg WPCP				129		129		282
Wallaceburg WPCP			131	146	131	146	183	219
Waterloo WPCP			730	193	730	193	990	257
Little River WPCP (Windsor)	3,038		5,812	3,347	6,387	3,918	6,387	3,918
Westerly WPCP (Windsor)			334	504	519	1,285	519	1,285
Woodstock WPCP		280	107	662	107	662	244	1,030
TOTALS	29,611	22,595	40,573	39,177	41,969	41,079	47,829	47,390

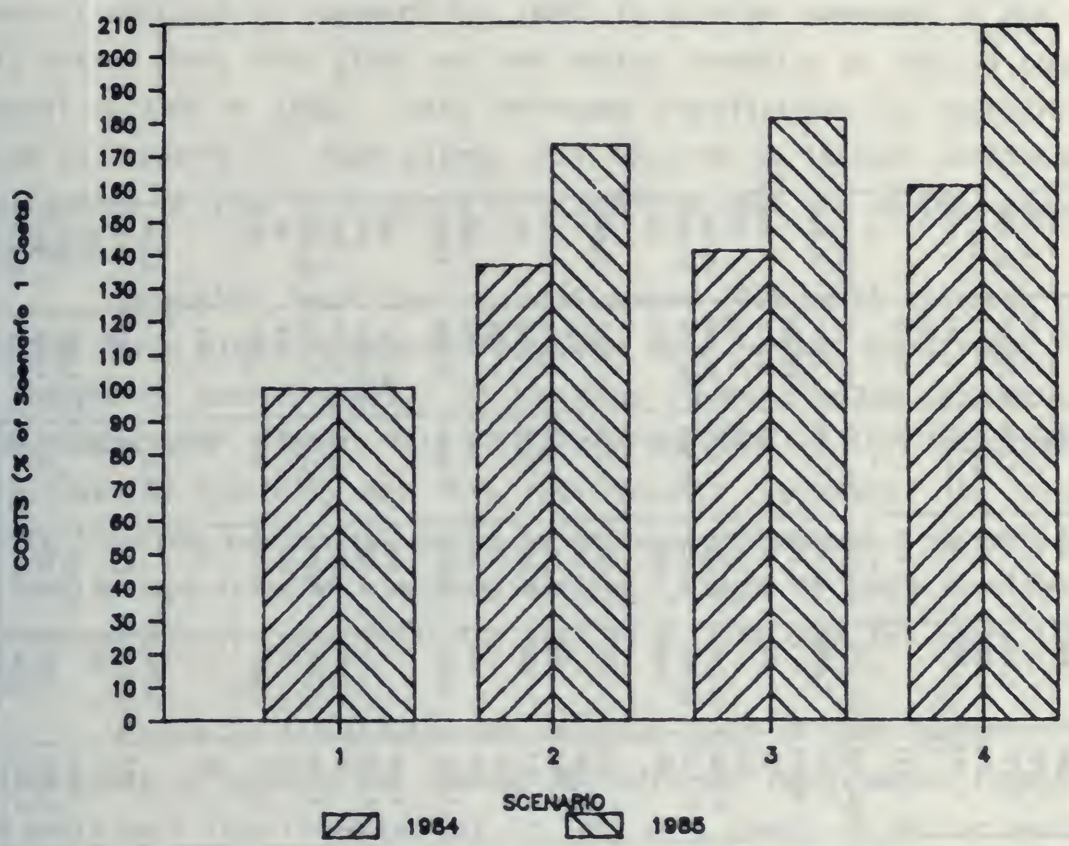

FIGURE 28 - RELATIVE COSTS TO IMPLEMENT PHOSPHORUS MANAGEMENT STRATEGIES IN THE LAKE ERIE DRAINAGE BASIN

TABLE 45. COSTS OF PHOSPHORUS MANAGEMENT STRATEGIES IN THE LAKE ONTARIO DRAINAGE BASIN

PLANT	SCENARIO 1		SCENARIO 2		SCENARIO 3		SCENARIO 4	
	1984	1985	1984	1985	1984	1985	1984	1985
Belleville WPCP [1]	--	--	--	--	--	--	--	--
Brockville WPCP	2,828	0	4,968	2,349	4,968	2,349	5,481	2,349
Skyway WPCP (Burlington)			1,188	107	1,188	107	1,323	240
Campbellford WPCP			240	894	240	894	267	1,325
Cobourg WPCP No. 1		3,678	10,721	7,767	10,721	7,767	14,164	9,779
Cornwall WPCP			8,713	7,336	8,713	7,336	12,587	12,226
Dundas			293	1,036	293	1,036	712	1,332
Anger Avenue WPCP (Fort Erie)			1,643	1,379	1,643	1,379	2,464	2,067
Baker Road WPCP (Grimsby)			7		7		20	23
Acton WPCP (Halton Hills)			133		133		172	
Georgetown WPCP (Halton Hills) [2]	--	--	--	--	--	--	--	--
Woodward Ave. WPCP (Hamilton)	129,896	185,649	259,753	278,474	340,926	292,397	340,926	292,397
Iroguois WPCP	2,044	2,848	2,044	2,848	2,044	2,848	2,044	2,848
Kingston WPCP			6,103		6,103		18,309	
Kingston Twp. WPCP			729	363	729	363	1,208	756
Highland Creek WPCP (Metro Toronto)			903		2,710	282	2,710	282
Humber WPCP (Metro Toronto)	19,643	5,115	21,636	12,786	25,499	16,036	25,499	16,036
Main WPCP (Metro Toronto)		20,110	21,112	52,157	34,421	69,543	34,421	69,543
North WPCP (Metro Toronto)			231	444	231	444	707	736
Milton WPCP								
Clarkson WPCP (Mississauga)			263	363	263	363	843	1,068
Lakeview WPCP (Mississauga)			138		219		219	
Napanee WPCP	6,273	788	6,341	828	6,341	828	6,735	2,514
Port Darlington WPCP (Newcastle)	3,520		4,007	259	4,007	259	4,260	345
Stanford WPCP (Niagara Falls)			598		598		598	
South East WPCP (Oakville)			421	949	421	949	655	1,394
South West WPCP (Oakville)			2,432	2,024	2,432	2,024	3,040	2,589
Orangeville WPCP								
Harmony Cr. WPCP 1 (Oshawa)	995		8,289		8,289		10,057	282
Harmony Cr. WPCP 2 (Oshawa)	1,024		8,532		8,532		10,352	290
Peterborough WPCP			734	1,581	734	1,581	1,239	1,924
York Durham WPCP (Pickering)		3,815	3,966	15,110	3,966	15,110	7,948	26,437
Picton WPCP			512	70	512	70	506	93
Seaway WPCP (Port Colborne)	584	388	1,179	815	1,179	815	1,395	903
Port Hope WPCP								
Prescott-Edwardsburgh WPCP			95		95	95	379	
Port Dalhousie WPCP (St. Catharines)								
Port Weller WPCP (St. Catharines)				5,015		5,015		9,574
Trenton WPCP		504	234	508	234	508	301	508
Welland WPCP				62		62		161
Corbett Cr. WPCP (Whitby)			831		831		1,384	124
Pringle Cr. 1 WPCP (Whitby)			1,209	350	1,209	350	1,406	458
Pringle Cr. 2 WPCP (Whitby)			1,555	730	1,555	730	1,951	1,113
TOTALS	164,788	222,895	381,753	396,604	481,983	431,445	516,282	461,716

1. Belleville WPCP was under construction in 1984.
2. Georgetown WPCP had equipment problems in 1984 causing atypical treatment efficiencies.

the Lake Erie Basin. There are two major reasons for this difference. A larger number of plants in the Lake Ontario basin requiring remediation use the more expensive alum for phosphorus removal. In addition, initiation of chemical addition at Woodward Ave. WPCP is a large component of the cost in this basin, since this plant was not adding chemicals to achieve phosphorus removal in 1984 or 1985. Costs increased significantly for Scenario 2 compared to Scenario 1. Most plants were required to improve performance for some period of time in Scenario 2 in order to meet the monthly average requirement.

Selective imposition of more severe (0.9 mg/L) effluent requirements at large plants (Scenario 3) results in a further significant increase in phosphorus removal costs. Of the five plants affected (Woodward Avenue WPCP, Humber WPCP, Toronto Main WPCP, Lakeview WPCP and Highland Creek WPCP), only Lakeview typically met this requirement. Therefore, the other four plants incurred substantial costs to improve performance. As anticipated, basin-wide imposition of a monthly average 0.9 mg/L TP limit resulted in the highest additional cost, totalling near $1 million over two years (1984 and 1985).

Figure 29 illustrates the relative costs of each Scenario relative to the costs of meeting the present MOE effluent requirements (Scenario 1). The costs were significantly less in 1985 as a result of better performance at a number of plants. Costs increased with the severity of the phosphorus requirement, to a maximum for Scenario 4 of 310 percent of the cost of Scenario 1 in 1984.

4.5 Summary

In the Lake Erie drainage basin, plant performance has exceeded the MOE requirement on a aggregate average effluent total phosphorus concentration basis throughout the period 1981 and 1985. Because of this performance, maintaining the total phosphorus loading to the Basin at the 1983 level will be difficult as flows increase in future years. Bringing all plants into compliance with the present 1 mg/L requirement on an annual basis would maintain the loading at less than the 1983 level until about 1987 or until the flow reaches 880,000 m^3/d. Imposing an effluent limit of 1 mg/L on a monthly basis will extend the time period about one year or until the flow reaches

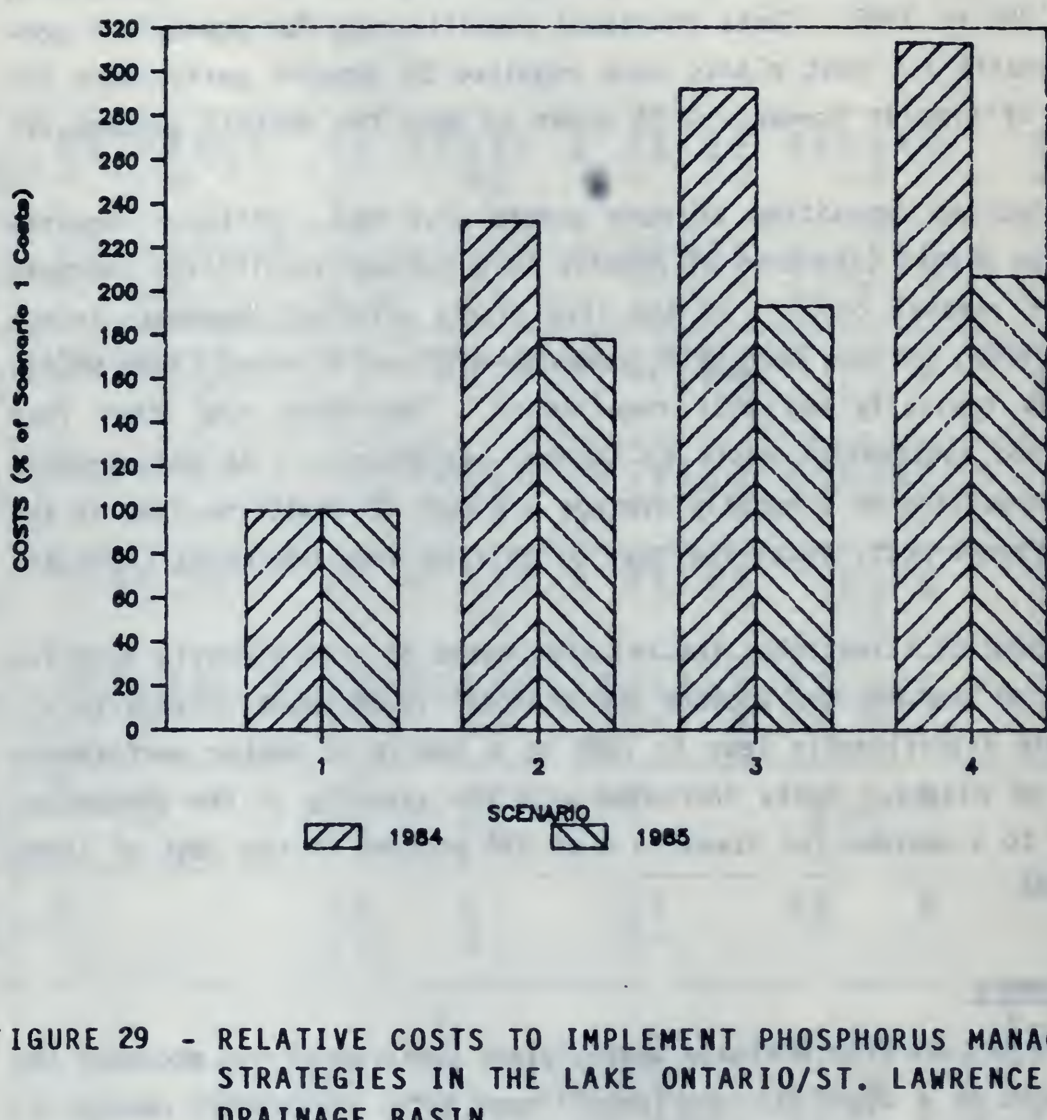

FIGURE 29 - RELATIVE COSTS TO IMPLEMENT PHOSPHORUS MANAGEMENT STRATEGIES IN THE LAKE ONTARIO/ST. LAWRENCE DRAINAGE BASIN

reaches 920,000 m^3/d. Imposing a more stringent requirement of 0.9 mg/L on some or all plants in the basin does not produce any further significant reduction in total phoshporus loading. The estimated costs of any of these phosphorus management strategies is relatively small, less than about $50,000 per year, because of the superior performance of most plants in the basin. Achieving large reductions in the total phosphorus loadings to the Lake Erie basin from large municipal WPCP's will require physical plant upgrading by the installation of tertiary filters to further reduce the aggregate average effluent phosphorus level to below 0.8 mg/L. Such upgrading will be capital cost intensive.

In the Lake Ontario drainage basin, where phosphorus removal performance has not been as efficient as in the Lake Erie basin, significant total phosphorus loading reductions can be achieved. Bringing all plants into compliance with the existing annual requirement will keep basin loadings below the 1983 level until 1990 or until the flow exceeds 3,000,000 m^3/d. Imposition of a monthly-based compliance requirement will maintain 1983 loading levels to almost 1995. Marginal further reductions are achieved by the application of lower effluent limits on some or all plants, at an additional annual cost of between $50,000 and $100,000 compared to the costs of applying a 1 mg/L limit on a monthly basis.

There was a significant linear relationship between the phosphorus loading reduction achieved and the costs of achieving the reduction in both basins as shown in Figure 30 (Lake Erie) and Figure 31 (Lake Ontario). It should be noted that plants were not actually attempting to achieve the requirements of Scenarios 2, 3 and 4, and therefore, costs may be biased. Based on these costs data, the average cost of achieving further reductions in phosphorus loading in Lake Erie was approximately $1,560/tonne compared to a cost of $2,660/tonne in Lake Ontario. The higher costs in the Lake Ontario drainage basin can be attributed to:

i) A greater percentage of plants using the more expensive alum instead of ferric or ferrous chloride

ii) The implementation of chemical addition to the Woodward Ave. WPCP (Hamilton) and increased sludge handling (dewatering and incineration) costs associated

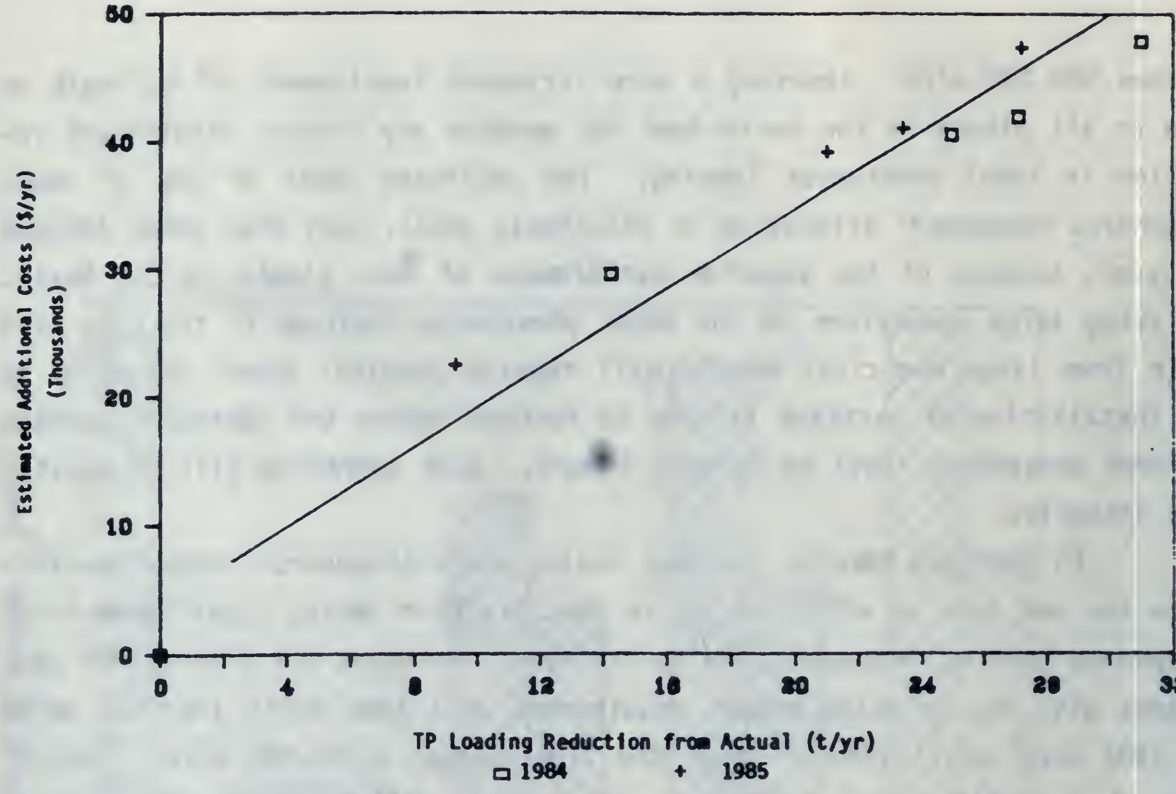

FIGURE 30 - ESTIMATED COSTS VS. PHOSPHORUS LOADING REDUCTION FOR THE LAKE ERIE DRAINAGE BASIN

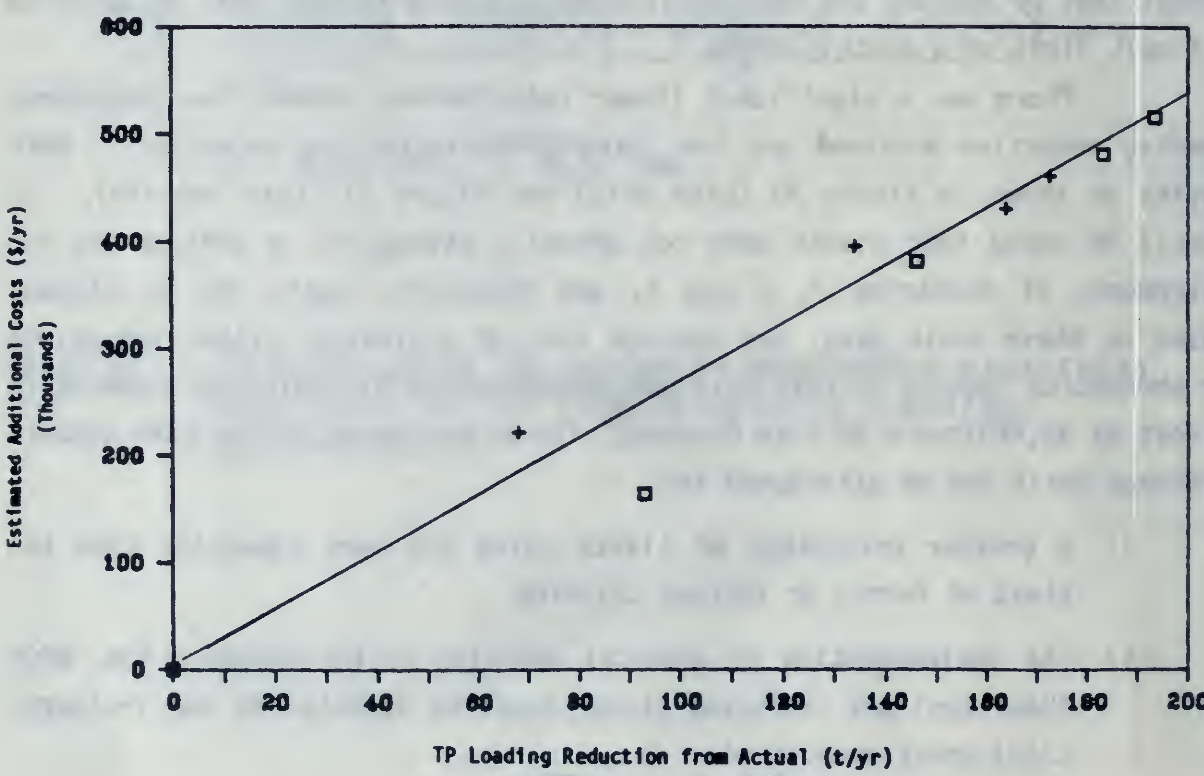

FIGURE 31 - ESTIMATED COSTS VS. PHOSPHORUS LOADING REDUCTION FOR THE LAKE ONTARIO/ST. LAWRENCE DRAINAGE BASIN

5.0 CONCLUSIONS AND RECOMMENDATIONS

5.1 Conclusions

The overall goal of the investigation was to establish the most cost-effective strategy of phosphorus management for municipal wastewater treatment facilities in Ontario, based on historical data review, field surveys and actual full-scale demonstrations of optimized phosphorus control techniques.

A number of key findings related to WPCP performance status and phosphorus removal upgrading were identified as a result of these investigations. These findings are highlighted below.

5.1.1 WPCP Performance and Compliance Status

- o There was an increase in the number of plants that complied with annual average effluent BOD_5, TSS and TP guidelines between 1981 and 1985, indicating a general improvement in plant performance during that time period.
- o There were significantly more plants that did not comply with effluent total phosphorus guidelines than did not comply with effluent BOD_5 and TSS guidelines in all years evaluated.
- o The aggregate average effluent TP concentration from municipal facilities discharging to the Lake Erie drainage basin and to the Lake Ontario/St. Lawrence River drainage basin was less than 1.0 mg/L in 1985. Facilities discharging to the Upper Great Lakes drainage basin exceeded 1.0 mg/L TP on an aggregate average basis in 1985.
- o A comparison of an 'annual average' method to a 'monthly average' method of assessing compliance showed that a larger percentage of plants are not in compliance based on the monthly average criterion. The largest increase is associated with compliance with effluent TP requirements. Based on the 'annual average' method of measuring compliance, a total of 21 plants would require improvements in their phosphorus removal performance based on 1985 data.

This compares to a total of 65 plants which would require improvements to meet the monthly average compliance requirements for total phosphorus. The majority of plants not complying on a monthly basis failed to comply less than 3 months of the year.

5.1.2 Factors Influencing Phosphorus Removal

- The three key factors identified as significantly influencing phosphorus removal performance were chemical dosage, clarifier hydraulic loading and sludge management practices.
- Chemical dosages adequate to maintain a molar metal-to-soluble phosphorus ratio of about 1.5 (based on primary effluent soluble phosphorus in conventional activated sludge plants) will ensure efficient phosphorus precipitation and consistent compliance if hydraulic loading or sludge management problems do not result in extended periods of high (>25 mg/L) effluent suspended solids concentrations.
- Higher chemical dosages can be applied to compensate for short-term effluent TP excursions related to hydraulic overloading. However, in WPCPs which experience extended periods of high hydraulic loading due to infiltration or spring runoff, consistent compliance with a monthly effluent TP requirement of 1 mg/L will be impossible regardless of chemical dosage without major capital expenditures.
- Consistent compliance with a monthly TP guideline will require increased sampling and analysis of effluent quality so that chemical dosage adjustments can be made in response to plant performance variations. Sampling should be conducted weekly as a minimum and 24-hour composite samples should be collected. Analyses for both total and soluble phosphorus fractions should be done and the laboratory programs should include adequate QA/QC samples to ensure that reliable data is generated. These data should be used to evaluate and adjust chemical dosage rates.

5.1.3 Basin Loadings

- o Total phosphorus loadings to the Lake Ontario/St. Lawrence River Basin and to the Lake Superior Basin from large WPCPs declined over the time period from 1981 to 1985. Loadings to the Lake Erie Basin were relatively unchanged over this period. Loadings to the Lake Huron Basin have increased since 1982; however, four facilities (Port Elgin, Sault Ste. Marie, Sudbury and Mikkola) had not implemented phosphorus removal programs by 1985. Implementation of phosphorus removal at these facilities should reverse this trend.

- o Because the large WPCPs discharging to the Lake Erie Basin achieved an aggregate average total phosphorus concentration of 0.89 mg/L in 1983, phosphorus loading reductions from these sources will be difficult to achieve by low capital cost operational procedures. Maintaining the 1983 phosphorus loading level as flows increase may require capital-intensive plant upgrading. Such capital projects will require sufficient lead time to ensure adequate planning and implementation.

- o In the Lake Ontario/St. Lawrence River Basin, where several large facilities did not comply with the annual average effluent TP guideline of 1 mg/L in 1983, bringing all facilities into compliance with their existing guidelines would maintain the basin loading at below the 1983 level until about 1990.

5.1.4 Phosphorus Management Strategies

- o Because of the superior 1983 performance of the large WPCPs discharging to the Lake Erie Basin, none of the phosphorus management strategies evaluated are capable of maintaining the 1983 phosphorus loading level to beyond approximately 1989. Imposition of a monthly-based compliance requirement of 1 mg/L will result in the basin loading being maintained for approximately one year longer than if the annual compliance evaluation approach is applied. The more stringent control strategies evaluated did not produce a significant reduction in loading in the Lake Erie Basin.

- All of the phosphorus management strategies assessed for the Lake Ontario/St. Lawrence river basin would result in the 1983 basin loading level being maintained to beyond 1990. Imposition of a monthly-based compliance requirement of 1 mg/L would maintain the 1983 loading level until about 1995, five years longer than would be achieved with the present annual compliance requirement. Imposition of a more stringent effluent quality requirement of 0.9 mg/L on some or all plants maintains the 1983 loading level for only about 2 years longer than would be achieved by the application of a monthly-based compliance requirement of 1 mg/L.
- In the Lake Ontario/St. Lawrence River Basin, the most cost-effective phosphorus management strategy is the imposition of a monthly-based compliance requirement of 1 mg/L total phosphorus. This approach will maintain the 1983 basin loading level until about 1995 or until the flow exceeds approximately 3,200,000 m^3/d. In the Lake Erie Basin, this management strategy will only maintain the 1983 loading level until about 1988 or until the flow reaches about 920,000 m^3/d. However, none of the other strategies investigated significantly increase the time-frame despite additional costs. To ensure a consistent policy on phosphorus removal, a monthly-based compliance requirement of 1 mg/L should be imposed on municipal facilities discharging to the Lake Erie Basin. At the same time, the allocation of phosphorus loading reductions to agricultural and municipal sources should be reproportioned in light of the high costs associated with further municipal source reductions.
- In developing phosphorus loading allocations and load reduction requirements, it is essential that the accuracy of the loading estimates be taken into account. Since analytical methods for total phosphorus may incorporate an error of more than 5 percent and flow measurements at municipal facilities may involve an error of more than 10 percent, it may not be possible to determine if a target load reduction equivalent to 5 percent or less of the total basin loading (approximately 10 tonnes/yr in Lake Erie and 50 tonnes/yr in Lake Ontario) has been achieved.

5.1.5 Upgrading Phosphorus Removal Performance

o In most cases, facilities can upgrade phosphorus removal performance to meet a monthly compliance-based requirement by improved monitoring and control of chemical dosage. Best Management Practice (BMP) should include:

- 24-hr composite sampling of plant effluent on a once per week basis.
- analysis of untreated and final effluent samples by the operating authority for both total and soluble phosphorus concentrations utilizing standardized analytical procedures.
- routine QA/QC programs to ensure accuracy of plant analytical techniques.
- adjustment of chemical dosage rate in response to the results of the routine sampling and analytical program.

5.2 Recommendations

5.2.1 Management of Phosphorus Loadings from Municipal WPCPs in Ontario

Based on the results of these investigations, it is recommended that:

o A monthly-based compliance requirement of 1 mg/L total phosphorus should be imposed on municipal WPCPs discharging to the Lake Erie and Lake Ontario/St. Lawrence River Basins.

o Best Management Practice (BMP) should be applied to achieve the monthly effluent concentration requirement of 1 mg/L TP. BMP should include:

- 24-hour composite sampling of plant effluent on a once per week basis.
- analysis of untreated and final effluent samples by the operating authority for both total and soluble phosphorus concentrations utilizing standardized analytical procedures.
- routine analytical QA/QC programs for plant laboratories
- adjustment of chemical dosage in response to the performance results.
- improved operator training in the area of phosphorus removal with particular emphasis on measurement and control of chemical dosage.

- In light of the capital-intensive facility improvements which will be required to achieve further significant municipal source reductions in the Lake Erie Basin, the allocation of phosphorus loadings to municipal and agricultural sources should be re-evaluated.
- Target phosphorus loading reductions in individual Great Lakes Basins should not be set at levels which are smaller than the error associated with the calculated total basin loading. It is estimated that this error is approximately five percent of the basin loading.
- MOE should develop and coordinate a laboratory QA/QC program so that dependable analytical data are generated at the plant level.

5.2.2 Further Study

Further work in the following areas is recommended:

- The implications of plant bypassing on total basin phosphorus loading, process operation and facility compliance status should be evaluated and a policy for plant design and plant operation developed which is consistent with the goals of Best Management Practice in these facilities.
- Further study should be devoted to determining if effluent quality guidelines and compliance requirements should be based on geometric mean concentrations rather than arithmetic mean concentrations since the geometric mean more accurately represents the skewed population distribution of effluent quality data.

6.0 REFERENCES

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